Development of a Conceptual Model for Anthropometric Practices and Applications Regarding Complete Garment technologies for the UK Women's Knitwear Industry.

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Abstract

To create garments that fit the body, anthropometric data must be utilised within the product development process. When producing woven garments a relationship between the garment and the body is determined at various different stages. This includes the construction of the basic block, the pattern making process and fit trials. The utilisation of anthropometric data within the manufacture of knitwear constructed and shaped on flat-bed machinery is not well documented. Because knitted fabric is extensible knitted garments have the ability to stretch and mould around the body. Determining the dimensions of these garments therefore must be considered specifically. The methods used to manufacture fully fashioned garments are also completely different and practitioners have to work within a limited set of parameters when creating the garment shape. Traditional fully fashioned garments are knitted as panels and then constructed. Advanced complete garment technology can knit, shape and construct a garment three dimensionally. Those at the forefront of technology development claim it provides the manufacturer with many benefits including improved fit. The utilisation of new technologies has been advocated as a way for UK knitwear manufacturers under threat from cheap imports to remain competitive. However the pace at which the technology has advanced has led to concerns about whether designers and technicians have the skills to fully exploit the machine capability and realise the potential benefits. Certainly to produce knitted garments with improved fit implies that the development process must utilise anthropometric data. Potential improvements in the knitted garment will only be of benefit if they are recognised and appreciated by the consumer

An investigation to evaluate the utilisation of anthropometric data within the development of complete garments and the impact of complete garment technology on product development was conducted. Mapping the UK industry provided a sampling frame for case studies with manufacturers utilising complete garment technology. The research employed qualitative strategies of data collection, including interviews and case studies. An analysis of consumer preferences regarding complete garments was also conducted using focus groups with women between the age of 40 and 55. This informed the development of a theoretical framework for female fit preferences relating to knitwear. The results revealed that seven companies were utilising complete garment technology within the UK. Case study analysis provided evidence to show that anthropometric data is not utilised within the development of complete garments but pre-established garment measurement is applied instead. The relationship between the garment and the body is only evaluated and determined during fit trials. Practices were heavily influenced by outdated methods and information which impeded the ability to design and develop complete garments autonomously. In addition designers and technicians do not have the skills to conceptualise and develop the 3D garment in relation to the body. Consequently they are reliant on the machine builders as the only providers of garment templates and skills support. The ability to create garments with fit improvement was also found to be hindered by this evident skills gap. In terms of garment fit, focus group analysis revealed that female consumers had very specific preferences that related to their body size and shape. They demanded garments that provided flattering fit and the theoretical framework reveals how this flattering fit is defined. Finally data from all the stages of the research was triangulated to develop a conceptual model for anthropometric practices and applications regarding complete garment technologies for the UK women's knitwear industry

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Chapter 1 Introduction

Anthropometrics, the measurement of the human body, is a complex science that calls for a defined methodology (Lasker 1994). In relation to clothing manufacture and the utilisation of anthropometric data there are a number of concerns including the development of methods of data collection and data analysis. Mass produced clothing requires that anthropometric data from populations must be collected and analysed to inform sizing systems that meet the fit demands of the consumer (Beazley 1996; Aldrich 2007). The importance of obtaining accurate and appropriate anthropometric data is demonstrated by the number of technologically innovative body scanning tools that have been developed to increase time efficiency when measuring the body (Treleavan 2007; Apeagyei 2010), and the high level of mass sizing surveys specifically for clothing, that have been conducted worldwide (Bougourd et al. 2001; Fan et al. 2004; Treleavan 2007; Sizemic 2010). Achieving good fit based on appropriate anthropometric data is recognised to increase sales and customer loyalty (Otieno 2000). The application of accurate anthropometric data during garment construction has been central to much discussion (Beazley 1996; Ashdown 1998; Aldrich 2001; Moore *et al* 2001; Fan *et al* 2004). The majority of research within this field, however appears to relate to woven garments. Those who have analysed the relationship between knitted fabrics and the body, suggest that a different approach to determining garment dimension (Aldrich 1996; Watkins 2006).

Knitwear produced on weft, flat-bed knitting machinery can be knitted as shaped panels which are then constructed as a separate process, a method usually termed as fully fashioned (Mills 1965; Walsh 1966; Spencer 2001). This technique creates the shaping for each panel within the knitting process (Eckert 2001) and therefore presents a unique set of problems when establishing fit satisfaction (Walsh 1966; Power 2008; Haffenden 2009). Documentation of how fit is achieved within this area however is limited. There are numerous publications that guide the reader through established methodologies on how body measurement is applied to cut and sew, woven garment manufacture (Bray 1986; Aldrich 2004; Joseph-Armstrong 2010). Within the field of fully fashioned knitwear however the equivalent information that explains how body measurement is converted to garment measurement is very limited (Sissons 2010). There are a number of different methods to create shape when knitting fully fashioned panels including; fashioning (increasing or decreasing the number stitches at the edge of a panel), changing knit structure, changing stitch length and integral shaping (moving stitches in the middle of a panel to increase or decrease) (Spencer 2001). Applying anthropometric data must therefore firstly consider these shaping methods. A complex set of skills are therefore required to achieve satisfactory fully fashioned knitwear that meets all the requirements (Guy 2001).

To facilitate good practice the development and use of size charts appropriate to knitwear has been recommended Power (2008). The lack of information regarding the application of anthropometric data for fully fashioned garment construction suggests new methodologies are also required to empower knitwear product development. Through the use of new technologies researchers are beginning to address these needs (Haffenden 2009; Black and Watkins 2010). However, these are projects that seek to develop made to measure garments. Methods used for mass produced garments within the UK fully fashioned knitwear industry appear to conform to a traditional model that has not been greatly modified in recent history (Mills 1965; Walsh 1966; Power 2008; Kumar Puri 2010).

Technological advances in flat-bed knitting machinery have created the ability to shape and construct knitwear on one machine, eliminating post production processes (Power and Otieno 2007; Brownbridge 2010). Garments therefore must be shaped holistically rather than as separate panels. In terms of the application of anthropometric data this development has generated further unknown fields of knowledge (Power and Otieno 2008). Particularly as the complete garment conforms to a tubular structure which suggests a completely new approach to shaping must be developed. Currently only Shima Seiki from Japan and the German company Stoll are commercially supplying specific complete garment technology. Complete garment technology is the culmination of many years of development and was greeted with much optimism at its commercial launch at ITMA in 1995 (Millington 1995; Gibbons 1995).

A considerable number of potential benefits have been identified regarding the utilisation of complete garment technology including: design innovation, Improved garment fit, improved comfort and the ability to produce custom made garments (Mowbray 2002; Karasuno 2000; Siddons 2007). Experts have however questioned whether the skills and knowledge to exploit the capability of complete garment technology are present in the workforce (Brackenbury 1992; Black 2001; Sayer et al. 2006). In addition there is some evidence from users of the technology that a lack of skills and knowledge has prevented fully satisfactory results being achieved (Troynikov 2008; Brownbridge 2010). Academics have called for specific courses in complete garment technology to be developed (Sayer et al. 2006) and the machine builders have invested in garment development to facilitate improvements for their customers (Shima Seiki 2010; Stoll 2010). In regards to the impact that complete garment technology has had on the product development process, specifically in relation to achieving fit satisfaction through the exploitation of machine capabilities, little is known.

The fit evaluation process has been acknowledged to be highly subjective, both within industry and for the consumer (Fan *et al.* 2004; Ashdown and O'Connell 2006). Claims made with regards to improved fit, facilitated by complete garment technology are therefore unlikely to be objective. As the technology is so novel and utilisation within the UK is currently very limited (Brownbridge 2010) no documentation relating to consumer's perceptions of fit regarding complete garments has been found. Furthermore, In terms of fit preferences no research that relates directly to any type of knitted garment has been found. Manufacturers who have implemented the technology have been reported to suggest that their retail customers are unaware that they are utilising innovative methods (Brownbridge and Power 2010). If this is the case, it is even less likely that the end consumer is aware of complete garments. The implied benefits of complete garments are of little consequence if they are completely unrecognised by the potential purchasers of the garment. However manufacturers suggest that the increased ability to create a diversity of garment design will influence the consumer to purchase (Mowbray 2007).

Through the literature review a number of knowledge gaps have been identified which present clear areas for new knowledge. The following five research aims have been identified.

Aims

1) To evaluate the extent and utilisation of complete garment technology within the UK clothing industry.

2) To analyse the utilisation of complete garment technology related to garment fit in the UK knitwear industries and the implied impact on product development.

3) To evaluate current anthropometric practices regarding size, fit and shaping in the UK knitwear industry.

4) To develop a theoretical framework for preferences of UK female consumers relating to size, fit and shaping of knitwear.

5) To develop an original conceptual model regarding the utilisation of anthropometric data related to complete garment technology for the UK women's knitwear industry.

Using a mixed methodology including: mapping the UK knitwear industry to determine a sampling frame of complete garment manufacturers in the UK, semi structured interviews with representatives from the machine builders, case studies conducted in the UK industry focussing on issues relating to the implementation of complete garment technology and finally focus groups with consumers to provide information regarding knitwear fit preferences.

Chapter 2 Literature review

2.1 Introduction

Chapter 2 focusses on anthropometric data, its procurement and application to clothing. The majority of the literature reviewed in this chapter applies to clothing in general terms or specifically to methods used for woven clothing manufacture. Very little documentation exists that distinguishes between the differing methods of garment manufacture and the potential variances that may occur regarding the application of anthropometric data. Unlike the manufacture of woven garments there is very little information that relates knitted garment development to body measurement. Chapter 3 will outline this issue in more detail.

2.2 Anthropometrics

The practice of anthropometrics is the measurement of the size, shape and proportion of the human body (Croney 1980; Roebuck 1995; Pheasant and Haslegrave 2006). The word anthropometrics derives from the Greek '*anthro'* and '*metreein'* meaning human and measure (Roebuck 1995; Fan *et al.* 2004). Although it is thought that the ancient Greeks used human measurement to establish a predisposition to disease (Jones and Rioux 1997), no clear explanation of the conception of anthropometrics has been found. Roebuck (1995) suggests that in the late eighteenth century, anthropometrics was used to classify ethnic groups, identify criminals and make medical diagnoses. Simmons and Istook (2003) suggest that anthropometry become a recognised discipline in the 1950s. Lasker (1994) however provides evidence of an anthropometrical committee within the British association for advancement of science in 1875. The committee's main concern was to establish standardised methods of measurement procurement in order to obtain accurate and consistent data. Despite this rich history, anthropometrics is a relatively new discipline in clothing science. The Standardisation of procurement methods are therefore still a major issue amongst contemporary practitioners collecting clothing specific data (Beazley 1996; Bougourd *et al.* 2000; Watkins 2006; Honey and Olds 2007; Lee *et al.* 2007; Petrova 2007).

2.3 Procurement and application of anthropometric data

It is recognised that product development requires a matching of the physical form of the product to that of its user (Pheasant and Haslegrave 2006). In relation to clothing this refers to how a garment fits the body. In order to develop successful clothing, it is first necessary to have some understanding of anatomy and the kinetic nature of the component body parts (Gill, 2008; Jenkyn Jones 2005). Consideration of the body must always initiate the garment development process (Otieno 1999). The process of developing clothes uses key measurements from an individual body and applies this to the garment construction process (Gill 2009). The construction processes used to develop the garment will influence how the anthropometric data is selected and utilised.

As the vast majority of clothing is mass produced, there is a need for a system of size classification to enable the consumer to select a garment that will most likely conform to their personal body measurement (Ashdown 1998). A sizing system must produce garments that meet the fit expectations of a population (Otieno 2008). To achieve this end it is necessary to procure and analyse anthropometric data from a population. Four factors of consideration can be identified in relation to the development of sizing systems (Tamburrino 1992a; Beazley 1996; Winks 1997; Lee *et al*. 2007; Gill 2008):

- It is based on anthropometric data that is current. Body size within a population changes over time, influenced by a number of factors, such as affluence, fashion, diet.
- It is based on anthropometric data that has been accurately and consistently collected using appropriate methodology.
- It is based on anthropometric data that reflects all the sizing inconsistencies within the population including variances in body shape.
- It is adequately communicated to the consumer, size coding used must be meaningful and easily identified.

American clothing manufacturers began to introduce systems of mass production by the end of the nineteenth century. However, in the UK at this time, small scale manufacture on an individual basis was still the norm (Aldrich 2007). Both World wars are thought to have further hindered the introduction of mass production in Europe and consequently sizing systems for mass production were first introduced in America (Tamburrino 1992a). These had to satisfy both the need to provide the most appropriately fitting garments for a population and the manufacturers desire to reduce costs by producing the smallest number of sizes possible, two factors that have been described as conflicting (Ashdown 1998). It is widely acknowledged that standardised sizing systems must accurately reflect a population in order to create customer satisfaction (Tamburrino 1992a; Beazley 1996; Langenegger *et al* 2002; Fan *et al* 2004).

2.3.1 Anthropometric data Collection for mass produced clothing

The first scientific sizing survey was conducted in the 1940s on approximately 1500 women in America (O'Brian and Sheldon 1941). The survey measured women manually testing a variety of equipment and methods. This became a model on which future surveys were based. The first UK Survey was conducted in 1951 to provide measurement data so individual clothing manufacturers could generate their own sizing systems (Kemsley 1957). For several decades women's size charts in the UK were based on this data. However it is difficult to gain any real understanding as to how the data from the 1957 survey was used by individual retailers. Kemsley (1957) recommended that at least three body shapes should be considered in order to satisfy the majority of the population and takes into account height and the drop value between the hips, the waist and the bust (the difference between the bust waist and hips). The proposal to accommodate more than one body shape however was never adopted by British retailers who only tend to produce size charts for one body shape (Bougourd 2007). Retailers have also adapted their size charts in order to more accurately reflect what they considered their customers' measurements to be (Jenkyn Jones 2005), creating a confusion of non-standardised sizing systems (Winks 1997; Bougourd *et al* 2000). Marks and Spencer conducted a sizing survey in 1986 (Fan *et al.* 2004). This data however remains confidential (Bougourd *et al.* 2000) and alludes to the asssumption that retailers regard sizing issues as a competitive area (Ashdown and DeLong 1995; Otieno 2000). In recognition that improvements were needed, another UK survey was conducted in 2001.

2.3.2 SizeUK

Technological development has provided new methods to measure the body and collect sizing data from a population. A number of sizing surveys have been conducted globally using body scanning technology (Fan et al. 2004). This study focusses on the UK industry and therefore critically reviews literature relating the last UK sizing survey. A collaboration of retailers and academics partly funded by the British government undertook an anthropometric survey in 2001. SizeUK took measurements of 5000 women and 5000 men and utilised white light scanning technology (Bougourd *et al.,* 2000; Bodymetrics 2005). This project was an effort to improve standardisation of size charts, clothing fit and size labelling in the UK. The utilisation of novel scanning technology created a number of challenges. Prior to survey commencement research to develop a sound methodology for the data collection was conducted. As the scanner is a non-contact measurement tool, software to accurately detect body landmarks (Section 2.3.3 p25) had to be developed. In addition it was necessary to formulate methods to determine appropriate posture, collect measurement data from under the arm and crutch and interpret the data for the development of size charts (Bougourd *et al* 2000; Fan *et al* 2004). Unfortunately, only key findings were made public. To access the full set of data involves making a purchase and the information is regarded as commercially valuable. Sizemic who are described as a 'spin off' of University College London, manage the SizeUK data, which it is claimed is owned by the retail companies who contributed to the research. Sizemic have built a package of products, ranging from basic access to the data, data analysis, 3D pattern generation through to actual products, namely fit mannequins (Sizemic 2011).

Because of the propriatory nature of commercial sizing, it is difficult to ascertain which retailers are using the SizeUK data. A large number of companies did however take part in the survey including Arcadia group, BHS, John Lewis Partnership, Marks and Spencer, Shop direct, Monsoon, Oasis, house of Fraser Speedo and Tesco. It is also difficult to draw any conclusions as to how successful SizeUK has been in improving sizing provision for the UK consumer. There are clearly still wide spread inconsistencies within the clothing market and consumer dissatisfaction with sizing is at a high level judging by the media interest since SizeUK (Shabi, 2004; Gusmaroli, 2006; Fox 2007; Smithers, 2011). Although the data that was released by SizeUK was limited, the information released claims to show a dramatic change in both size and shape of women's bodies since the 1950s survey (Bougourd *et al.* 2000; Taylor 2004), (Table 2.1). SizeUK claimed that the average woman's waist measurement was found to have increased by 16cm compared to the increase of both the hips and the bust (3.5cm) suggesting that the average women is no longer an hourglass shape (Section 2.6.1). (Bowcott 2004; Jenkyn Jones 2005; Freeman 2006).

Table 2.1 Comparison of average female measurements from 2001 and 1951.

Source of measurement	Bust	Waist	Hips
Average sized woman (SizeUK 2001)	98	86	**103**
Average sized woman (Kemsley Survey 1951)	94	70	**99**

Beazley (1998) developed size charts through manually measuring 100 women aged 18-28 in 1998. A comparison between this size chart data and SizeUK data also reveals a discrepancy in the waist dimension and therefore a change in body shape. The average bust measurement found by SizeUK is 2cm larger than a size 16 on Beazley's size chart. The hip measurement is 3cm smaller than Beazley's size 16. The waist measurement however is much larger than Beazley's size 16. In regards to the average waist measurement found by the SizeUK survey, it is so deviant to previous findings that it suggests a difference in the methodology used to obtain the measurements (Section 2.3.4).

Table 2.2 Comparison of data of average women from SizeUK with selected size chart data

Source of measurement	Bust	Waist	Hips
Average sized woman (Kemsley Survey 1951)	98	86	**103**
Size 16 (Beazley 1998)	**96**	**78**	**106**

Bourgourd (2000) acknowledges that the 1950s survey measured the subjects in their underwear which was likely to have constricted the waist to a fashionably small dimension. Indeed, scrutiny of Kemsley's (1957) photographic documentation clearly shows how the foundation garments worn by the participants constrained the waist. This does not however explain the dramatic variance between Beazley's findings and SizeUK's findings regarding the relationship between the waist, hips and bust. Beazley however only measured 100 18-28 year olds which is likely to produce slightly biased results. In addition, Beazley's survey procured measurement manually which may also help to explain the data discrepancies.

Watkins (2006) asserts that sizing surveys do not necessarily result in better sized clothing. The application of measurement within clothing practices is equally important. It is not known whether practitioners within the clothing industry have the skills to interpret and utilise the extensive data made available through scanning technology. Researchers in the field of measurement procurement stress the importance of standardisation of survey procedures (Bougourd *et al.* 2000; Honey and Olds 2007), particularly if data from different projects are to be compared. It is also clear through comparative analysis (Table 2.1) that the general size and shape of a population does not remain static over time. At the time of Kemsley's (1957) survey it was likely that food rationing would have influenced the size of the participants. Surveys therefore need to be conducted on a regular basis, which is costly and time consuming.

2.3.3 Landmark demarcation

This section critically reviews the methodology used to categorise the body regions that are measured when obtaining data specifically for clothing manufacture. Landmarks are points on the body, between which, measurements are taken, such as the nape of the neck and the centre back waist. Landmarks are also used to indicate the longitudinal level of a girth measurement (Beazley 1996). Many authors stress that precision is crucial when allocating landmarks in order to obtain measurements that accurately reflect the key measurements needed for garment pattern construction (Kemsley 1957; Tamburrino 1992a; Beazley 1996; Bougourd *et al.* 2000; Simmons and Istook 2003; Connell and Presley 2005; Honey and Olds 2007, Gill 2009).

Procedures for locating landmarks have been developed and documented by a number of researchers who have conducted previous surveys that measure manually. (O'Brian and Sheldon 1941; Kemsley 1957; Beazley 1996). Kemsley's (1957) research located the landmarks in groups that collectively define key body areas needed when cutting a pattern for woven garments. The armscye line for instance is determined through the location of four landmarks; the shoulder point, the armscye posterior and anterior (the points at the front and back of the body where the trunk of the body joins the underarm forming folds of flesh) and the underarm. The relationship between the key body regions and the points used when constructing a pattern for woven garments is recognised during data collection (Kemsley 1957).

Landmarking the body for clothing acknowledges that certain body measurements are particularly important such as the bust, waist and hips (girth), the nape to waist and the nape to knee (length) when cutting patterns (Armstrong 1987; Aldrich 2004). The need for precision and accuracy is also acknowledged as is the need for the standardisation of methods. Haffenden's (2009) study, specific to shaped weft knitted garments, developed landmarks that complied with the particular age demographic of her subjects. This suggests that age may influence the methods needed to landmark female bodies. In relation to the procurement of data for clothing it appears that developments in knowledge are still required, particularly for specific demographics and when utilising novel tools such as body scanning technologies (Honey and Olds 2007; Gill 2009).

2.3.4 Standardisation of body measurement methods

It has been recognised that sizing inconsistencies within the clothing industry is a source of dissatisfaction (Winks 1997; Otieno *et al.* 2005). The International Organisation for Size Standardisation (ISO) was set up in an attempt to establish a system of sizing standards that could be used in a global market (Winks 1997). As body measurement data collection precedes any other procedure in the formation of clothing size charts, the ISO made attempts to standardise body measurement procurement. To that effect ISO 8559 (1989) describes with diagrams how to manually measure women when conducting anthropometric surveys. Although the directions are clear and use anatomical details to identify key landmarks, the document leaves much scope for individual interpretation. Simmons and Istook (2003) clearly state that imprecise methods when locating landmarks will lead to erroneous results and list three different methods of locating the waist each of which is more clearly described than those in the ISO8559 standard. The waist is a circumferential measurement which can vary in length depending on how near to the hips or ribs the measurement is taken. Other dependent measurements taken in relation to the waist, (such as waist to knee) will be affected by an imprecise methodology. This example demonstrates why those practicing anthropometry have been so concerned with standardisation of methods of measurement procurement (Lasker 1994)

2.4 Development of sizing systems

Sizing systems provide a framework through which clothing manufacturers can categorise a range of pre-determined sizes for a given population (Kunick 1994; Winks 1997). They therefore rely on a good source of anthropometric data which appropriately reflects the said population (Otieno 2008). A sizing system will be made up of a size roll, a range of sizes which have fixed steps or increments to divide one size from another. The method used to determine the size range and the increments within a size roll varies depending on each clothing market sector and individual retailer (Winks 1997). The fact that sizing systems have been developed by individual retailers has resulted in non-standardisation and inconsistency. Although efforts have been made to

One method of tackling the plethora of different sizing systems currently being used is to identify the key body measurements on which the garment size has been based (Chun Yoon and Jasper 1995; Winks 1997)

2.4.1 Sizing codes

2.4.2 Vanity sizing

Honey and Olds, Kennedy,

Vanity sizing is a term used to describe a strategy used by retailers to flatter women into thinking they are a smaller size than they expected by modifying size coding changing to larger sizes are coded to read as a smaller size (Treleavan 2007). Sizing systems are being used not as a consistent means to meaningfully communicate the garment size, but as a marketing tool. Vanity sizing is recognised to increase sizing inconsistencies between retailers.

2.5 Data application: pattern construction woven garments

A basic block is the foundation tool which establishes the fit of garments and is based on anthropometric data. It is the process that translates the 3D body data into 2D patterns for woven garment manufacture. For mass production the block should fit an average figure based on data from sizing surveys. Alternatively blocks can be developed using the body measurements of an individual for made to measure clothing. Once developed the block is then manipulated to create the desired garment style (Aldrich 2004; Joseph-Armstrong 2010).

It is common for literature documenting the development of basic blocks to provide a size chart of body measurements and an illustration showing where each of these specified measurements fall on the body (Bray 1986; Shoben and Ward 1987; Beazley and Bond 2002; Aldrich 2004; Joseph-Armstrong 2010;). This data tends to vary, Aldrich (2004), for instance, provides a chart that shows standard measurements that she suggests correspond to UK sizes 10 – 24. These are graded in 5cm increments and a size chart listing the dimensions for descriptive size codes S, M, L which is graded using 6cm increments. Joseph-Armstrong (2010) however provides information specific to the American market. There is also a degree of variance in the methods provided to guide the drafting process. However they all follow a set of steps that plot the key body dimensions on paper, using points, straight line and right angles. The armhole depth for instance is drawn in at a 90 degree angle to the line that squares the shoulder point to the centre back. The armhole is plotted out using half the back width measurement plus 0.5cm, (this determines the width of the armhole on the back of the garment, half the chest measurement (this determines the width of the armhole at the front of the garment) and the armhole depth plus 0.5cm (this determines the armhole depth) (Aldrich 2004). The additional 0.5cm represents the ease that is added to the body measurement in order to create a garment that allows the wearer to move. Using this method to create the basic block enables the designer and the pattern cutter to clearly see how body measurement has been used to create a shape that conforms to specific key body measurement.

2.5.1 Modelling: A three dimensional approach

An alternative method of creating woven garments that conform to a desired set of body dimensions is to model directly on to a dress stand, representing the 3D human form (Silberberg 1997). This method of garment development is suggested to be helpful for fashion designers as it enables a three dimensional approach (Mee and Purdy 1987). The basic principles of modelling involve moulding fabric onto a 3D body form to create the desired garment shape. These fabric pieces are then carefully translated into paper pattern. The literature reviewed identifies the importance of using a dress stand that is representative of the desired body shape and size (Silberberg 1997; Di Marco 2010). Mee and Purdy (1987) however suggest using a stand with dimensions that are smaller than the desired size and padding it to create the specified shape, plus ease. The importance of creating garments that fit the body through appropriate use of anthropometric data is identified as a priority (Mee and purdy 1987; Di Marco 2010).

2.6 Body Shape

Many researchers have recognised that body shape is an important issue that as yet has not been addressed within mass production (Tamburrino 1992b; Beazley 1997; Winks 1997; Connell and Presley 2005; Lee *et al.,* 2007). People within a population may share the same key anthropometrical measurements although posture and figure discrepancies may well be diverse. Standard sized clothing, developed to fit one particular body shape will therefore not fit all (Beazley 1996; Aldrich 2004). Beazley (1997) collected data from 100 university students and found that when the bust measurement was subtracted from the hip measurement, the difference varied between 4cm to 22cm. A considerable variance of body shape was therefore found within a fairly small and homogeneous population.

It is suggested that clothing retailers consider their sizing systems to be a commercial asset (Simmons *et al.* 2004a). Related information is therefore proprietary leading to a situation where it is not possible to ascertain what body shape retailers are basing their garments on. It is only possible to speculate that those informed by SizeUK data will no longer be using an hourglass model, as the female body shape was found to have radically changed since the 1950s (Section 2.3.2 p23). However consumers of mass produced clothing in the UK are still only being offered garments based on the body shape selected by the retailers (Bougourd 2007). This situation is likely to limit the number of consumers who will be fully satisfied.

2.6.1 Body shape classification

A number of studies have been conducted worldwide in an attempt to improve knowledge regarding the variety of body shapes within specific populations. Sheldon (1940) pioneered research utilising photographic methods as a means of body shape categorisation. Sheldon's system, samatotyping, acknowledges that the shape of people's figures tend to be irregular, Three major body types were classified, which were then sub divided to depict a huge range of individual figure types (Croney 1980). Sheldon's work influenced others who have used his system of classification to gain insight for a variety of applications. Within the field of clothing samatotyping has been used to classify body shape to apply to sizing systems (Tsang et al., 1998). Sheldon's work was not however developed specifically to apply to clothing manufacture which more recent research has attempted to address.

Body scanners (Section 2.3.2) have since, provided a tool to enable a more sophisticated analysis of body shape, enabling researchers to identify new methods of classification. Two methods have been identified. Connell et al. (2001) used experts to visually assess three dimensional body scans for the development of a software format for body shape analysis. The shape analysis system was a method that assessed the body using ten pre-selected categories such as: Hip shape, body build, abdominal shape, buttock shape and bust shape. The findings showed that methods using subjective judgement do not provide clear results. 206 out of 547 evaluations had to be re-scored.

Gupta and Gangadhar (2003) aimed to develop an easy to follow statistical model for body size chart development. They classified body shape through the use of key dimensions. Through analysis of measurement data from 2095 Indian women the bust and hip measurement were identified as the most critical girth measurements. Body shapes were classified through determining the relationship between the hip and the bust, a triangular body shape, for instance, has a bust 6 inches smaller than the hips. Further categories were made representing three pre-determined body heights. These categories were made for specific use when compiling size charts.

Simmons et al. (2004) comparatively analysed 254 body scans to a set of size standards that are currently used by the American clothing industry. The sizing standard that produced the best fit for the widest range of subjects was found to only comply with at best 48% of the measurements taken from all the subjects. They then developed a system for classifying female body shape for mass customisation. Mathematical descriptors were used to define the shapes that had been initially identified through a literature review (hourglass, oval, triangle inverted triangle and rectangle). Analysis of scan data from 222 subjects found that many subjects fell outside of the original five body shape classification. Four more body shape categories with descriptive names; spoon, diamond, bottom hourglass and top hourglass were therefore generated. Numerical values were determined for each of these new shape descriptors (Table 2.3). Two of the body shapes (oval and diamond) are not defined by the numerical descriptors. The authors state that this system of shape analysis attempts to define every female body shape using the smallest number of classification categories. The findings were built into a software package, *The Female Figure Identification Technique* (FFIT). Devarajan and Istook (2004) conducted further research using a population of 887 to validate the FFIT system.

Lee et el. (2007) applied FFIT to a comparative study on Korean and American women's body shapes. This system acknowledges the range of differing girth proportions within a population, there is no distinction however between differing vertical measurements such as height and leg length.

Table 2.3 The FFIT system of body shape classification

Body shape classification	Shape identification: determining factors (Simmons *et al.,* 2004a; Simmons *et al.,* 2004b)	Shape identification: determining factors (Lee *et al.,* 2007) (Measured in inches)

Hourglass	A small dimensional difference between the hips and bust. The difference between the hip to waist and bust to waist are about equal and significant.	If (bust-hips) < = 1 Then
		If (hips – bust) < 3.6 Then
		If (bust-waist) > 9 Or (Hips-waist) > = 10
		Then shape = "Hourglass"

Bottom Hourglass	A larger hip circumference than bust circumference. The ratios of bust to waist and hips to waist are significant enough to produce a defined waist.	If (Bust-hips)> = 3.6 And (hips to bust <10. Then
		If (hips-waist)> = 9 Then
		If (highhip/waist)<1.193 Then
		Shape = "Bottom hourglass"

Top Hourglass	A larger bust circumference than hip circumference. The ratios of bust to waist and hips to waist are significant enough to produce a defined waist.	If (bust-hips)>1 And (bust-hips)<10 Then
		If (bust-waist) . =9 Then
		Shape = "Top hourglass"

Spoon	A larger circumferential difference between their hips and bust, bust to waist ratio is lower than the hourglass shape and hip to waist ratio is great	If (hips – bust) > 2 Then
		If (hips – waist) > = 7 Then
		If (highhip/waist) > = 1.193 Then
		Shape = "Spoon"

Rectangle	Bust and hip measurement relatively equal, bust to waist and hip to waist ratios are low, no discernable waist.	If (hips-bust) < 3.6 And (bust-hips<3.6 Then
		If (bust-waist <9 And (hips-waist <10 Then
		Shape = "Rectangle"

Diamond	Stomach, waist and abdomen measurements are higher than the bust measurement. Rolls of flesh around their middle section.	Not defined
Oval	Rolls of flesh at the large body midsection, abdomen, stomach, waist measures less than the bust.	Not defined

Triangle	Larger hip circumference than bust circumference. Ratio of hips to waist is small, no defined waistline	If (hips-bust)> = 3.6 Then
		If (hips-waist<9 Then
		Shape = "Triangle"

Inverted Triangle	Larger bust circumference than hip circumference. Ratio of bust to waist small, no defined waist.	If (bust-hips)> = 3.6 Then
		If (hips-waist)<9 Then
		Shape = "Inverted Triangle

2.6.2 Body shape classification: standardisation

The need to classify body shape is widely recognised (Sheldon 1940; Croney 1980; Devarajan and Istook 2005; Lee et al. 2007). The identification of this need however has generated a multitude of proposals for systems of body shape classification. This may well provide further opportunities for inconsistency, causing confusion for the consumer.

Academic researchers have not only proposed varying systems of body shape classification but methods of identification also vary. A diversity of coding for each body shape category also exists; descriptive terms range from comparisons to geometric shapes: rectangle and triangle (Simmons et al. 2004), subdivisions of these such as bottom and top hourglass (Lee et al. 2007) and common objects such as pear, apple and hourglass (Connell et al. 2001). Numerical codes have also been proposed to distinguish body shape within new sizing standards (Adendorff et al. 2010). Add to this, recommendations made by competing commercial companies, advising retailers on sizing strategies (Alvanon 2011: Sizemic 2011) and the potential for inconsistency increases.

Popularisation of the use of body shape classification has been achieved by media celebrities such as Gok Wan (Wiseman 2010) and Trinny and Suzanna (Woodall and Constantine 2008). Their proposed classification of body shape introduces even further inconsistencies. Therefore although the consumer is likely to be familiar with the concept of classification, if sizing systems are ever going to accommodate more than one body shape the issue of standardisation must be addressed.

2.7 Garment fit: evaluation

The evaluation of fit is a complex process through which the relationship between the garment and the human body is assessed (Ashdown and DeLong 1995; Loker *et al.,* 2004; Borrogaard 2005; Chatteramann and Rudd 2006). Ashdown and O'Connell (2006) identify two separate occasions when fit is assessed on commercial garments. Firstly the manufacturer will make an evaluation. Secondly the customer will assess the garment for fit usually before making a purchase. Standard industry practice used to achieve garment fit is to assess the garment on a model, whose body conforms to a company's sample size (Ashdown and O'Connell 2006; Pisut and Connell 2007). This process has been criticised for relying on subjective personal judgement (Ashdown and DeLong 1995; Fan *et al.,* 2004; Ashdown and O'Connell 2006). Bye and LaBat (2005) conducted research specifically related to fit trials in the American clothing industry. Findings showed that garments are regularly fitted two to three times before being approved. In addition the fit model was not measured before each fitting. The authors suggest that fit trials serve multiple purposes and tend to include design modification and assessment of the aesthetic. It appears to be difficult to separate the aesthetic assessment with a fit assessment as one is very reliant on the other. The practice of relying on fit trials to create satisfactory garment fit, appears to be deeply ingrained within the clothing industry. Design students are encouraged to continually assess new designs on bodies or dress forms (Jenkyn Jones 2005). This enables aesthetic and fit assessment to take place and affirms the relationship between the garment and the body.

The fit evaluation process conducted in industry will result in a sample garment that retains the size, shape and proportion of the model who may not be representative of the average body (Bougourd 2007). Arguments that body shape variation should be accommodated within sizing systems must therefore be valid (Sections 2.3.2). The current approach to achieving good fit has been identified as the cause of consumer dissatisfaction (Ashdown 1998; Otieno *et al.,* 2005; Honey and Olds 2007; Lee *et al.,* 2007). Some UK companies who have access to scan data from surveys are selecting their models to be more representative of their target market (Bougourd 2007). This may create some improvements but garments will still only conform to one particular body shape.

2.7.1 Objectifying the evaluation process

Attempts have been made to find methods that create more objectivity within fit evaluation procedures (Ashdown and Delong 2995; Ashdown et al. 2004; Ashdown and O'Connell 2006; Chen 2007). Ashdown and DeLong (1995) examined wearer perceptions regarding dimensional change at specific locations of a garment. Industry experts were used as participants and assessed the garments whilst wearing them. The study revealed that they could consistently detect a dimensional change as small as 5mm on the waist of trousers. A different approach was to use experts to rate 3D images of participants wearing trousers (Ashdown et al. 2004). Experts were asked to judge between acceptable and unacceptable fit using their own empirical knowledge on which to base their assessment. It has been claimed that there was a limited number of specialists with enough experience to conduct effective fit evaluations within the industry (Ashdown and O'Connell 2006). Subsequent research to develop a framework for assessing fit was conducted. This was based on one set of guidelines originally authored in the 1960s (Erwin and Kinchen 1969). These guidelines are concerned with maintaining technical standards such as straight of grain and seam lines that conform to a specified direction. Although there is no doubt a need for developing better systems of fit evaluation to inform industry practice, it must be acknowledged that the aim of fit assessment within industry is to satisfy the consumer. It is therefore important that fit assessment criteria should be informed not just by expert opinion and traditional industry specific guidelines (Erwin and Kinchen 1969) but through an understanding of consumer fit expectations. These guidelines were clearly developed to be used to evaluate woven garments. They use criteria that relate to the warp and weft of a woven fabric and would therefore not translate to knitted garments without major modification. Ashdown and Delong (1995); Ashdown et al. (2004); Ashdown and O'Connell (2006) and Chen (2007) all conducted research that was specifically related to the evaluation of woven garments. However as de Klerk and Tselepis (2007) acknowledge the influence a fabric has on the physical comfort, aesthetic appearance and fit of a garment is considerable. An evaluative assessment of the fit of a knitted garment for instance would have to acknowledge the impact of the properties of a knitted structure and its subsequent relationship to the way the garment moulds to the body. No recommendations equivalent to the fit assessment framework utilised by Ashdown and O'Connell (2006) has been found for weft knitted shaped garments.

2.7.2 Knitted garment: fit evaluation

Watkins (2006) identified a lack of knowledge within the area of fit analysis for cut and sew knitted garments (Section 3.3 p45). She also questions the validity of using pattern cutting methods which adapt patterns originally constructed for woven garments (Aldrich 1996; Aldrich 2004) Watkins's (2006) subsequent research developed a technique for objectively assessing the fit of garments, cut and sewn from a knitted fabric. A body suit was made with no darts or construction allowances for body contours. A grid of 25mm squares was marked on to the fabric. The contortion of the squares into different geometric shapes allowed for identification of areas of fabric stretch. In this way it was possible to assess whether garment fit was achieved through accurate proportioning related to body size and shape or through deformation and extension of the fabric. Watkins' methods are likely to be intuitive for those who already have pattern cutting and garment fit assessment skills as it utilises visual techniques of fit evaluation, assessing the garment on the body. This complies with methods frequently used within industry (Fan *et al.,* 2004; Bougourd 2007).

Other methods of assessing extensibility of knitted fabrics mathematically (Postle 2002) could be related to garment fit. These methods are however likely to be more difficult for designers, pattern cutters and garment technologists who may not have the relevant skills to interpret the mathematical equations used. No documentation has been found to show how practitioners within the knitwear manufacturing and retailing industries expect a knitted garment to fit the body. The evaluation process and the definition of levels of acceptability are therefore difficult to ascertain. In addition, studies relating to female consumer's fit preferences have not been found to make any reference to knitwear. A knitted garment is likely to conform to a greater variety of body shapes than a rigid woven garment. However the lack of objective research within the field of consumer fit preferences relating to knitwear leads only to speculative assumptions. Borrogaard (2005) for instance, suggests that larger sized consumers are likely to have an aversion to knitted garments that cling and mould to their figure. It is important for knitwear producers to understand the complex issues relating to the fit of a knitted garment.

2.8 The achievement of fit satisfaction within a population

2.8.1 Introduction

Satisfying the consumer must be of primary consideration for both manufacturers and retailers. Theories applying to consumer satisfaction stress that it is the distinction between the consumer's expectations of a product and the actual performance of the product that determines satisfaction (Otieno 2000). Mass produced garments must therefore meet the consumer's expectations in order to achieve satisfaction. It is the identification of these consumer expectations that presents a complex and difficult challenge. It is therefore important for manufacturers to understand how the consumer evaluates garment fit. The results for the retailer of not satisfying consumers is costly and there are some alarming statistics published that claim high levels of fit dissatisfaction Treleavan (2007) suggested that 60% of consumers claim to be dissatisfied with garment fit

2.8.2 Consumer fit evaluation

De Klerk and Tselepis (2007) explored the relationship between fit evaluation, fit expectation and fit satisfaction experienced by adolescent females consumers. This research recognised that garment fit when judged by the consumer includes a complex set of criteria. Functional characteristics, such as comfort, aesthetic characteristics such as the ability to flatter the body, suitability for the occasion and adherence to current fashion were all identified as factors that influence consumer fit preferences. The researchers acknowledged that these young consumers were unaware of the fit standards adhered to by experts, such as straight seams and correct grain lines. They suggest that other aspects of the clothing, such as brand names, price and place of purchase are potentially more important to achieving consumer satisfaction. Research that attempts to identify what it is that influences the consumer regarding garment fit however must confront a challenging number of possible variables. de Klerk and Tselipis (2007) acknowledge this, and outline four intrinsic and six extrinsic influencing factors (Table 2.4).

Table 2.4 Factors of influence identified by de Klerk and Tsepelis

influencers of fit evaluation	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Intrinsic Factors	fabric	Style	Size	Ease		
Extrinsic factors	Peer group opinion	Fashion	Brand name	Feeling good	Feel in control	Feeling of fit-in

Apeagyei (2008) conducted twelve semi structured interviews and 132 self-administered questionnaires to gain insight into factors of influence on consumers' clothing purchasing practices. Although the research does not include practical fit evaluation sessions questions directly relate to the process of consumer garment evaluation. Results from the questionnaire show a large percentage (77%) of respondents indicate experiencing problems with garment fit. Although there is further suggestion of specific body locations causing fit problems, the information gained through the administration of questionnaires is general. Therefore there are limitations in using this type of research for expanding knowledge and understanding on the decision making process that is fit evaluation, and would be difficult to apply to if attempting to solicit information about specific clothing products such as knitwear. An example of this limitation is the claim that 56% of respondents agreed that it was possible to assess how well a garment fits just by looking at it. This may provide indication as to some consumers' approach to fit evaluation, but unless additional information is provided with statements that indicate specifics such as necklines, waist dimension or sleeve length the meaningful value is restricted.

Experts acknowledge that a greater understanding of fit preferences would increase garment manufacturers' ability to provide garment sizing that satisfies fit demands (Anderson *et al.,* 2001; Jenkyn Jones 2005; Pisut and Connell 2007). This section outlines some of the influencing factors regarding consumer fit preferences through a review of existing literature. Methodology used to gain insight into consumer fit preferences will also be examined.

Pisut and Connell (2006) drew attention to a perceived lack of understanding of the relationships between fit preferences and body shape. They argued that although many clothing manufacturers still utilise the hour glass body shape as standard, most recent findings show that a higher percentage of women are wider at the hip than the hourglass shape and therefore a re-evaluation of practices are required. Apeagyei's (2008) study also acknowledged body shape. The findings indicated that female consumers not only select clothing that they perceive enhances their body shape, they are also aware that their individual body shape can cause fit dissatisfaction if it does not conform to the body shape standard used by clothing manufacturers.

Body image has been defined as an individual's constructed perception and subjective feelings relating to their body (Rudd and Lennon 2001 Chatteraman and Rudd 2006). Weight norm is a term that refers to cultural standards that a society sets regarding health and personal attractiveness (Offer 2001). For several decades studies have shown that weight norms have been decreasing (Silverstein *et al.,* 1986; Turner *et al.,* 1997; Offer 2001; Silverstein *et al.,* 2006) whilst actual body weights within a population have been increasing (Bowcott 2004; Freeman 2006; Zaninotto *et al.,* 2006). If these studies are correct there must be implications for the clothing industry. Garments must not only fit correctly according to a set of variables (Section 2.7.1 p33), but they must satisfy a consumer's desire to look attractive. Research suggests that clothing can be used by individuals to emphasise or disguise what are considered to be positive or negative body characteristics in an attempt to conform to beauty ideals (Rudd and Lennon 2001; Chatteramann and Rudd 2006; Apeagyei 2008). Women have also been found to blame their bodies if clothing does not fit (Grogan 2008)

The current relationship between female attractiveness and thinness arguably should be considered when designing and developing garments. Current industry practice is to design and produce sample garments in a size 10 or 12 (Jenkyn Jones 2005; Bougourd 2007), yet according to the findings from SizeUK the average woman is much larger (Table 2.2 p25). If garments are only developed for small female bodies it is unlikely that the process fully addresses the need to flatter larger figures. It is also questionable whether the appropriate skills and knowledge to enable this type of design approach is prevalent within the clothing industry.

Age is also a factor of consideration in relation to fit preferences and the body. Haffenden (2009) argued that as the female body ages, it changes shape. As a consequence, older women have difficulties finding clothing that accommodates their fit preferences. Mintel (2008) report that older women (over 45) are least likely to be happy with the choice of clothes on offer. Many in this category are influenced by fashion but also perceive a need to dress in an appropriate manner for their age. No specific studies however have been found that explains further these perceptions of age appropriateness in reference to body image. In the UK, 48% of the adult population are over 45, clear justification for manufacturers to gain further understanding into the fit preferences of the aging consumer.

2.8.3 Methodology previously utilised for investigating fit preferences

Chatteraman and Rudd (2006) conducted an exploratory study to identify the relationship between physical and social psychological characteristics of the body and their relationship to female consumer aesthetic preferences. A questionnaire measured consumer preferences regarding garment styling, such as the shape of a neckline, sleeve length and silhouette. Only a small percentage (20.5%) of the given population (1000) responded to the online survey, even though small monitory incentives are offered.

To measure the participant's preferences regarding the aesthetic attributes of clothing, a semantic differential scale was used, utilising a set of adjectival opposites to measure the participants' attitudes (Bradley and Lang 1994). Visual representations were also used in order to clarify the range of choice given to the respondents. Chatteraman and Rudd

(2003) also used visual representations to measure consumer attitudes to garments categorised as 'tops' and 'bottoms'. To measure body image and body cathexis, instruments developed through previous research were used: The body image avoidance questionnaire asked the subject to rate 19 statements of body image related behaviour such as "I wear baggy clothing".through a 5 –point likert type scale. A body cathexis scale; participants were asked to rate specified body regions through a 5 point likert type scale

The questionnaire also asked the participants to give their size in terms of standard clothing size such as size 12 (US) (L). The study found correlations between lower body image and greater body coverage. The link between body cathexis and aesthetic preference was less definite but findings did suggest that lower body satisfaction weakly corresponds to greater body coverage. The findings relating to body size showed that subject with a larger body size showed a preference for clothing that provides greater body coverage. The authors do however highlight the limitations of this research as the survey was only of one age range and was low in number. There was however no acknowledgement of consideration for the influence of fashion on consumer preference regarding aesthetic styling.

Pisut and Connell (2007) surveyed 1026 women aged between 19-54 with a self-administered questionnaire. The objectives of this study were to identify specific body regions where women experience fit problems, to determine fit preferences regarding specific clothing categories, To determine the relationship between fit preferences, body shape and body cathexis and to determine the relationship between fit preferences, body shape and demographic and personel information. The questionnaire was divided into four sections, sections 1 and 2 were concerned with demographics, shopping habits and fit problems experienced by the participants. Section 3 investigated body cathexis. A modified version of the body cathexis scale (Mahoney and Finch, 1976) was utilised. This measures participants' satisfaction with a total of 19 body regions using a likert type scale of satisfaction. Unlike Chatteraman and Rudd (2006) who posed questions concerning body cathexis related to the whole body, Section 4 asked respondents to identify their body shapes by selecting from a range of illustrated figures. Preferences regarding garment style were also measured in section 4. The participants were presented with a choice of flat sketches representing a variety of garments showing differing styles such as a variance of ease.

Connell et al. (2002) used focus groups as an exploratory method to gain insight into consumer's attitudes to mass customised clothing, with the aim of building a model of mass customisation for the clothing industry. Seven focus groups were conducted with no more than 12 participants per group. The proceedings were audio recorded and transcribed. A pre-established coding guide was used in the initial analysis. In addition the participants' comments were all coded as registering satisfaction or dissatisfaction. Secondary codes were then applied. Age, location and computer literacy were used to segment the focus group participants. Comparisons were made between the differing group segments and summaries for each group were prepared. The coding was reviewed again and a model was constructed. The model building process initially identified two key model components. This led to the identification of common needs expressed by the consumers. It was found that concepts and phenomena identified in literature emerged from the focus group data. This was used when building the model. The model is built up of a range of shapes, each of which represents a set of clearly defined concepts. These are then interlinked, showing the relationships between the concepts. The technology that can enable mass customisation for instance identified as body scanners are represented by diamond shapes. Star shapes were used to represent the potential mass customised options created through the use of body scanners such as the choice of design options. Arrows and symbols show the relationship between these concepts and the possible barriers to consumer acceptance.

Holmlund et al (2011) adopted an experimental methodology to explore how mature women aged between 50 and 63 purchase clothing. Observations of women shopping were conducted in a department store. Field notes recorded these observations. Additional Face to face, in depth interviews were conducted with a sample of 12 women. The interviews were audio recorded and transcripts were made. The interviews explored issues that relate to fit preferences, such as general attitudes and opinions towards clothes. The data was analysed firstly by coding and categorisation. Then emerging categories from each interview was compared and grouped into more general classes or themes. The final stage of analysis was to define the relationships between the categories and build a model. The study does not explain how the observational data was analysed, but it infers that it was combined with the interview data and analysed using the same method.

2.9 Chapter Summary

Studies that have focussed on the relationship between anthropometric data and clothing manufacture indicate there is still a body of research and development required within the field. Anthropometric data is required both to inform the development of sizing systems for mass produced clothing and during the garment construction process to create a garment that complies or fits a specific body.

To develop effective sizing systems anthropometric data must firstly be collected from a selected population. Data procurement methods appear to have been developed specifically to apply to pattern making for woven garments (Beazley 1996; Gill 2010). There is a lack of information in the public domain that relates to the utilisation of anthropometric data for knitwear. However it is clear that methods of garment construction vary considerably between the knitwear and woven garment manufacture. In addition fabric properties must be accounted for. It is therefore likely that in relation to the procurement of anthropometric data, methods do not directly relate to knitwear. An understanding of which key measurements are necessary to define knitwear dimension must be determined in order to ensure effective procurement ensues (Power 2008; Power and Otieno 2008; Haffenden 2010). Dissatisfaction with sizing provision is reported to be at a high level in the UK (Fox 2007; Smithers, 2011). These reports however make no distinction between woven and knitted garments. It is therefore unknown if the dissatisfaction is general or specific to particular types of garment.

Studies also show that in order to develop effective sizing systems for massed produced clothing, there is still a need for general improvements in methods used to collect, analyse and organise anthropometric data (Ashdown 1998; Bougourd 2000; Honey and Olds 2007). Although the lack of standardisation of sizing systems has been identified as a problem for consumers (Shabi 2004; Otieno *et al* 2005), the sizing survey conducted in 2001 (SizeUK) has done little to challenge the situation as the data has never been published. The standardisation of anthropometric procurement methods is also difficult to achieve, despite intervention from the ISO. New technological tools such as 3D body scanners exacerbate this non-standardisation as new methodologies have had to be developed (Bougourd 2000) There may well be deviances between measurements taken from a scanned body and those taken manually. Non-standardisation of procurement methods will impact on survey findings. The difficulties of defining the waist highlight one specific problem that has caused inconsistency when extracting measurement for size charts Table 2.1 & Table 2.2 p25. Recognition of these inconsistencies will help to increase accuracy within size chart development and as the field of sizing for clothing develops, methodologies will improve and knowledge will develop.

Researchers who have analysed sizing survey data have identified that a variety of body shapes exist within a female population. Systems of body shape classification have been developed in the hope that they will inform a more sophisticated approach to size chart development. (Connell *et al*. 2001; Simmons *et al*. 2004; Lee *et al.* 2006). Women who have a body shape that does not comply to the size charts used in industry will undoubtedly experience fit compromises. The degree to which garment fit is compromised may be dependent on the fabric type and its properties. It is possible to predict for instance that an extensible knitted garment has higher fit tolerance levels than a pair of jeans. No published data however has been found that relates to consumer experience when seeking knitwear that fits. In relation to body shape classification and its potential to inform size charts, industry practitioners need to know whether these size charts are relevant to their specific product. For example, if fabric extensibility prevents consumers from detecting fit compromises, size charts that recognise body shape are less relevant. If however as Borrogaard (2005) suggests, the moulded fit of a knitted garment causes dissatisfaction to consumers who prefer to conceal parts of their bodies, then recognition of body shape for knitted garments would be relevant. Studies regarding consumer fit preferences recognise the need to identify and determine aspects of garment fit that influences consumer satisfaction. However no previous studies have been found that relate directly to knitwear preferences.

Although the need to improve garment fit has been acknowledged and much research has been conducted to try to inform progress, very little of this work relates directly to knitwear. Whether consumers have specific preferences when relating to knitwear, how the fit of knitwear is evaluated and what garment characteristics they seek when selecting for purchase is largely unknown.

Chapter 3 Knitwear development

This chapter investigates literature specifically related to the knitted garment. Construction and shaping methods for weft knitted garments are explored. Machine developments which have the potential to innovate knitted garments are critically reviewed and the potential implications on industry practices have been evaluated. The ability to identify methods of anthropometric application within the manufacture of knitted garments has been found to be problematic. Unlike literature that relates directly to woven garment development, most published data that provides a guide on the knitwear development process excludes any detailed information regarding how body measurement relates, or is applied to the garment.

3.1 The Weft Knitted Structure

A knitted fabric is constructed through the formation of yarn into intermeshed loops. Weft knitted fabric can be produced on machines with two opposing horizontal needle beds (straight bar or flat-bed machinery). These consist of rows of needles inserted into a metal plate (Raz 1993). To create the fabric, loops are formed on the needle bed one row at a time. These rows are drawn through the previously constructed loops which are then released from the needles, suspended from the newly created loops. A line of loops running across the width of a knitted fabric is called a course. The loops running down the length of a knitted fabric are known as the wale (Brackenbury 1992; Spencer 2001).

It is possible to produce a diverse range of differing knit structures by manipulating the direction through which one loop intermeshes its neighbouring loop. Figure 2.1 shows a face loop and a reverse or back loop.

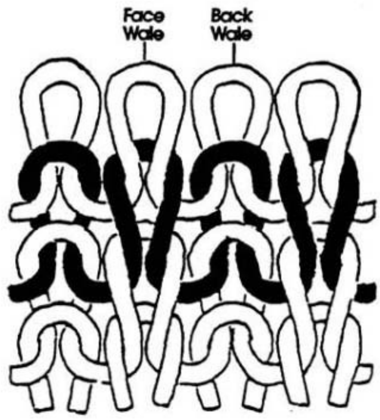


Figure 3.1 Rib knit structure showing face and back loops (Textlilearticles 2009)

3.1.1 Loop configuration: the impact on the weft knit structure

Raz (1993) identifies three basic groups of knitted structures: Plain structure consisting of loops which are all identical and intermeshed in the same direction to create either all face loops or reverse loops. A plain knit constructed on a flat-bed machine uses only one needle bed. A rib structure is made of alternating face and reverse loops. On the flat-bed machine this is achieved by pulling a face loop through each needle on the two opposing needle beds. This creates what is referred to as a 1 x 1 rib. A variety of ribs can be produced by varying the number of needles used a 2 x 2 rib for instance is created by alternating face and reverse loops two at a time. Purl structure consists of alternate courses of back and face loops. The flat-bed knitting machine knits a course on one needle bed. These are transferred to the opposite bed and a course of reverse loops is knitted.

Figure 3.2 Basic knitted structures

Each different knit structure has a range of differing properties. A knitted rib for example collapses across the width when relaxed, decreasing the dimensions of the width and increasing the thickness of the fabric. When tension is exerted along the rib courses the fabric is reported to extend up to 120% (Brackenbury 1992). Spencer (2001) claims a rib reduces by 30% of its knitted width when it is relaxed. A purl knit contracts longitudinally. It therefore has more lengthwise elasticity than a rib or plain knitted structure (Raz 1993). A plain knitted fabric extends more across the courses than the wales (Brackenbury 1992; Raz 1993). In terms of garment fit these differing properties can be exploited to enable shape to be created. A knitted rib for instance that collapses in width when relaxed will reduce the width of the garment if it is integrally incorporated into a plain knitted garment without compromising comfort. Rib structures are therefore frequently incorporated into garments at strategic regions such as the cuff and the waist, to create shape whilst maintaining a comfortable fit. It is also possible to change the way a loop is formed. This will impact on the properties of a knitted structure (1.1.1.1Appendix A p286).

3.2 Anthropometric data application

The structure and properties of a knitted fabric influence the way a knitted garment fits the body. Postle (2002) demonstrated that weft knitted fabric has two way extensibility. Knitted fabric can mould itself to a 3D shape through deformation (Power 2004; Watkins 2006; Power and Otieno 2007) which suggests four way extensibility (across the courses, the wales and the bias). These properties will impact on the way a knitted garment will relate to body dimension. No specific data however has been found that explains how the stretch properties of knitted fabric are quantified in order to calculate garment dimension when constructing knitwear. Power and Otieno (2007) recognised that knitted structures differ greatly from woven ones, rendering anthropometric related knowledge used within the woven industry non-transferable. A subsequent investigation focussed on the relationship of anthropometric data and knitwear sizing, styling and fit. Power and Otieno (2007) identified a knowledge gap created by advanced methods of knitwear manufacture in regards to size and fit and further research was recommended.

There are specific limitations regarding the way garments knitted on flat-bed machines can be shaped (Section 3.4). If shape is created through adding or reducing stitches, the smallest dimension that can be gained or reduced will equal the stitch length. This limitation will have an impact on how anthropometric data is applied as it is not possible to create the required dimensions with the same precision as is possible when cutting garments (Power 2008). Unlike garments that are cut from fabric pieces (cut and sew) the process of knitting garments to shape creates the fabric at the same time as the garment shaping (Eckert 2001). Garment dimension therefore must be specified before the fabric is knitted.

Power (2008) outlined the influence that advancements in flat-bed machinery has had on shaping the garment. This in conjunction with fashion influences is suggested to have created a demand for shaped knitted garments that fit closely to the body. In recognition of this, Power (2008c) argued for the development and use of size charts, specifically appropriate to knitwear. It was also acknowledged that no pattern for shaped knitted garments is constructed during product development. This acknowledgement implies that it is not just knit specific size charts that are needed but a methodology to apply these measurements in order to empower knitwear designers to exploit technological advancements.

3.2.1 Stitch dimensions

To determine the size of a garment knitted to shape on a flat-bed machine, a calculation based on the number of measured loops or stitches in a given area of cloth is made, known as the stitch density (Mills 1965; Raz 1993; Guy 2001; Spencer 2001). The method used to make this calculation is to knit a sampler or swatch and then count the number of loops within the specified area (Walsh 1966; Brackenbury 1992; Eckert 2001; Power 2008c). Mills (1965) acknowledges that stitch density will vary within a given area of any knitted fabric and therefore it is difficult to be exact. He therefore sets a number of guidelines such as the use of only finished dimensions (once the fabric is relaxed) in order to standardise his methods. Power (2008c) is more specific and claims that there is a difference between the stitch density on the sleeve and the body of a garment. This should be acknowledged when calculating panel dimensions. The garment pressing process which uses a frame to maintain garment dimension (known as boarding) will affect the stitch density To accommodate these Power (2008c) recommends that the sampler is bagged out (constructed as a tube). An evaluation conducted before bagging out provides the calculation for sleeve stitch density. The sampler is pressed on a frame slightly wider than its width and then re-evaluated to provide stitch density for the body. Black and Watkins (2010) also acknowledge that samplers need to be made for each garment section in order to calculate stitch density. These recommendations are founded on knowledge developed empirically. They provide a rare insight into knitwear related practices. Walsh (1966) also suggests that as well as calculating stitch density, loop length is determined. This was achieved by un-ravelling yarn from a pre-calculated number of loops, measuring this under test conditions determines the length of each loop.

3.3 The weft knitted garment

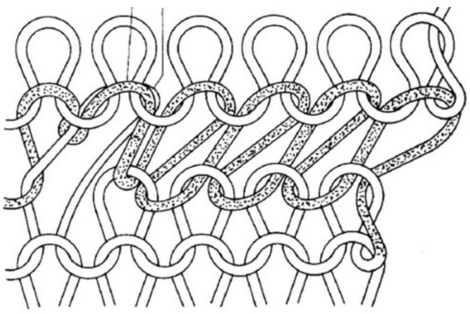
Power (2008d) classifies four types of weft knitting machinery: circular, fully fashioned, flat-bed and complete garment. Circular knitting produces a tube of fabric which is often cut down one side and opened out to create a flat length of fabric (Brackenbury 1999). Knitwear produced on circular machinery is not however a focus for this study. Fully fashioned garments are knitted as shaped panel pieces then constructed using a separate post-production process (Spencer 2001). Traditionally fully fashioned garments were produced on straight bar machines. However, developments in flat-bed knitting machinery, originally only used to produce lengths of knitted fabrics, have since greatly reduced the cost of producing fully shaped knitwear (Power 2008d). The ability to produce complete garments on flat-bed machinery is a relatively new development and is discussed in more detail in section 3.6. Knitted garments that are cut from knitted cloth (cut and sew) are shaped in a similar way to woven garments and are therefore not discussed further.

Secondary sources list four ways to create shape and vary the dimensions when producing fully fashioned weft knitted garments (Mills 1965; Guy 2001; Spencer 2001)

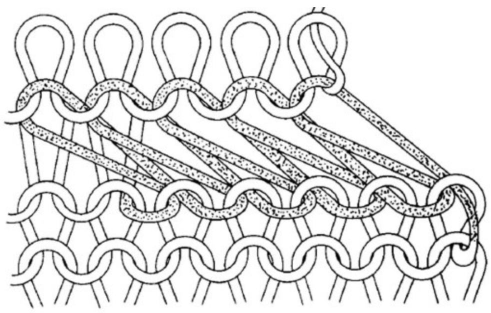
1. Changes of the construction of the knitted structure, such as a plain knit to a knitted rib (Section 3.1)
2. Alteration of stitch length.
3. Fashioning - widening the fabric width by transferring a loop onto a needle outside the selvedge edge, narrowing the width by transferring a loop to a needle inside the one that the loop was previously attached. This needle will then cease knitting. (Figure 3.3)
4. Integral fashioning – a number of needles transfer creating a loss or gain in fabric dimension within the body of the fabric. Wale shaping is when the number of wale loops are reduce internally, flechage or course shaping reduces the number of loops in every course (Brackenbury 1992)

3.4 Shaping the fully fashioned garment

Prior to construction fully fashioned panels are knitted to shape on the machine. Fashioning, specifically widening or narrowing, is a method that is clearly associated with the fully fashioned garment



Wale fashioning (Widening)



Wale fashioning (Narrowing)

Figure 3.3 Shaping the garment: fashioning

(Spencer 2001)

The angle created by the fashioning process can be controlled by the number of courses that are knitted between each fashioning course (fashioning frequency). It is also possible to transfer more than one loop at a time to create a more acute angle.

3.4.1 Garment shape: fashion frequency.

Spencer (2001) provides guidelines for calculating the fashioning frequency, which in this case creates the shape of the garment body. It is suggested that firstly the measurements that relate to the garment length (shown in blue Figure 3.4) are converted into course numbers. Spencer's example shows the dimensions in inches. If the inches are converted to cm this means that the calculation will refer to 2.5cm rather than one inch. This must be accounted for in the calculation so each length must firstly be divided by 2.5 then multiplied by 20 which is the number of courses per 2.5cm which will have been pre-established through swatch analysis (Section 3.2.1 p44). The same calculation will then be made using the measurements specified for the garment width (chest, neck and waist shown in red Figure 3.4). This will indicate the number of needles needed to achieve each of the three dimensions.

The chest is the widest section of the garment, the neck and the waist are narrower. Spencer (2001) then suggests that the total number of needles that need to be decreased between the neck and the chest and the waist and the chest are calculated by simple subtraction. These sum totals must be divided in two as the subtraction must be equally divided between the left and right side of the garment. Once these figures have been established it must be decided how many single-needle widening or narrowings (which will reduce or increase the number of needles by one) are needed and how many double needle widenings or narrowings (which will reduce or increase the number of needles by two). All the calculations relate to achieving the decrease in dimension from chest to neck and waist, yet no consideration of how the garment shape created by the fashionings relate to the body. Compared to woven garments, this method of creating garments produces a very simple shape, which is two dimensional with no shaping to allow for body curvature. In addition the front and the back of the garment are dimensionally the same before the neck is cut. The properties of the knitted fabric therefore are being heavily relied upon to create garment fit.

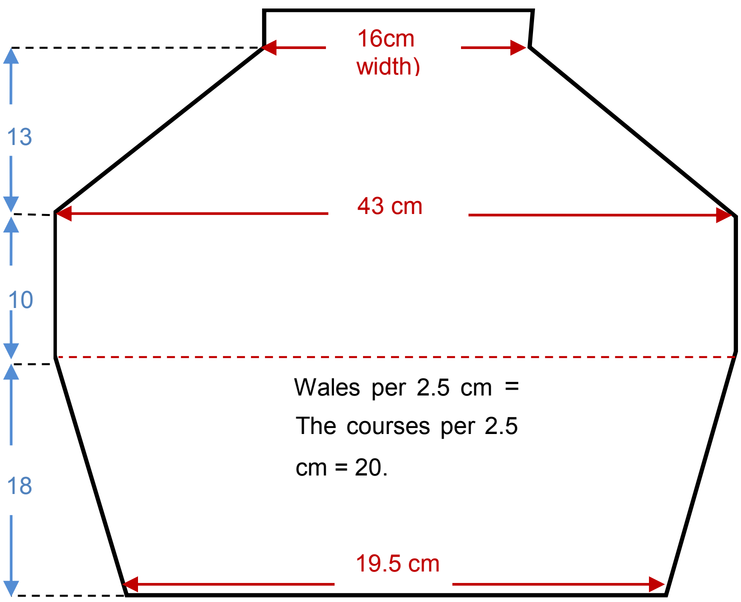


Figure 3.4 Calculation of fashion frequency: creation of garment shape
(Adapted from Spencer 2001)

Like Spencer (2001), Mills (1965) details the machine mechanisms and their functions that enable the shaping procedure. This attention to technical detail is typical of publications providing guidance for the production of fully fashioned knitwear. The approach is full of specific terminology and not easily accessible for readers needing to understand the basics of shaped knitwear construction. His description of methods used to calculate fashioning details on a garment, included below, illustrates this inaccessibility.

"Fashioning details will always be calculated from the first to the last fashion mark inclusive; that is the number of courses between the first and last fashioning in a sequence may be obtained by subtracting one from the total number of fashionings and multiplying the answer by the course frequency. The total number of courses may be obtained by adding one to the product" (Mills 1965 p203).

This passage does not include diagrams or illustrations that relate to the garment or the garment's subsequent relation to the body. Mills (1965) does not acknowledge the relationship between the garment and the body in his guidelines to produce fully fashioned shaped garments.

Through varying the fashion frequency a curved armhole shape is created very much like that of the woven patterns. It is also clear that shaping can be used to create specific curves, so a sleeve head shaped to the body is possible, by varying the fashion frequency (Power 2008c). It must however be acknowledged that the minimum unit of change is the length or width of the knitted stitch and this is a limitation that must be accounted for. Sissons (2010) provides guidelines on how to convert basic pattern shapes into data stitch by calculating the fashion frequency. There are however very few examples found in literature to show how knitted panels can be constructed through the application of pattern cutting theory. It is however possible to adopt a sophisticated approach to by combining pattern cutting skills with a good working knowledge of knit specific skills such as the limitations of fashioning on flat-bed machinery and the properties of knitted structures.

3.4.2 Determining the dimension of the fashioned panel

Walsh (1966) recognised that industry methods were based on the application of empirical knowledge and trial and error. This prompted research to scientifically define the methodology for determining the specification for a fully fashioned garment, after the size and shape of the garment has been specified. Within the introduction of the document it is stated that the primary consideration when constructing a garment to fit the body is the application of appropriate anthropometric data. A reference is made to prior sizing surveys (O'Brian and Sheldon 1941; Kemsley 1957). Walsh (1966) however asserts that it is not his aim to address body measurement data related to achieving fit satisfaction. This statement is clearly demonstrated as the methods that are outlined to define the garment dimension do not relate to body measurement only garment measurement. To determine the neckline of a garment, for instance, Walsh (1966) suggests using formulae relating to sections of a circle. There is however no reference to the shape and dimensions of the human neck. The implication is that the author is using empirical knowledge regarding the way a garment region (in this case the neckline) fits the corresponding body region (the neck). It must also be acknowledged that the crew neck garment that Walsh (1966) is describing will have to be pulled over the head. There is however no mention of how the dimensions of the neck of the garment relate to head dimensions. This again implies that empirical knowledge relating to the ability of the knitted fabric to stretch and recover is being used to guide the determination of the dimension of the neckline. How knitwear manufacturers approached the complex issues of covering the female body with all its contours and curves is not addressed by Walsh. It is also unknown whether the skills and knowledge to apply body measurement data is present within the industry.

Mills (1965) sets out methods for the construction of a number of knitted garments. He provides dimensions and translates these to needle use, calculating numbers of courses and wales. The garments are broken down into component parts such as the waist, the bust, the skirt rib. At no point however is body dimension referred to, pre-established garment dimensions are used. Both Walsh (1966) and Mills (1965) appear to be concerned with how to achieve shaped garment panels that will fit together properly. The relationship with the body and the garment pieces appears to be implicit. This is unlike the process of constructing woven garments where each pattern piece is related to a body region first and then to its adjacent part.

Table 3.2 (p24) shows the key dimensions used to determine knitted garments for the upper body. It reveals that pre-established garment dimensions are used to define the knitted garment. Only one source of literature has been found that refers to the utilisation of body measurement within the development of knitwear. Sissons (2010) provides a very simple guide to inform knitwear designers how to use body measurement to construct a basic block (2.5 p27). Unlike block construction for woven garments, no ease is added to the body measurements implying that fit is dependent on the stretch properties of a knitted fabric. The width of the block is determined by the bust measurement which is commonly the widest upper body girth measurement. No suppression is included to shape the waist and there is no differentiation between the back and the front block. Using the block pattern, stitch density and fashion frequency is calculated, transferring the pattern data to knitting data.

Eckert (2001) asserts that designers invariably put inaccurate or incomplete measurement data on the specification for the technicians. This, it was claimed caused inconsistencies as measurements are mutually dependent and suggests that designers are unaware of the importance of accuracy when drawing up knitwear specification. Power (2008c) provides guidelines on how to determine the specification for a knitted panel garment with a set in sleeve. This reveals some specific industry practices which Power (2008c) acknowledges are based on empirical knowledge. The shoulder width, for instance, is always knitted 2cm less than the dimension specified as it is known to stretch, because of the weight of the sleeve. The neck dimension is also reduced to allow for stretch when the trim is applied in post-production. These adjustments, carried out by knitwear practitioners after garment dimension has been determined, highlight the fact that specifications provided to knitwear manufacturers are inappropriate.

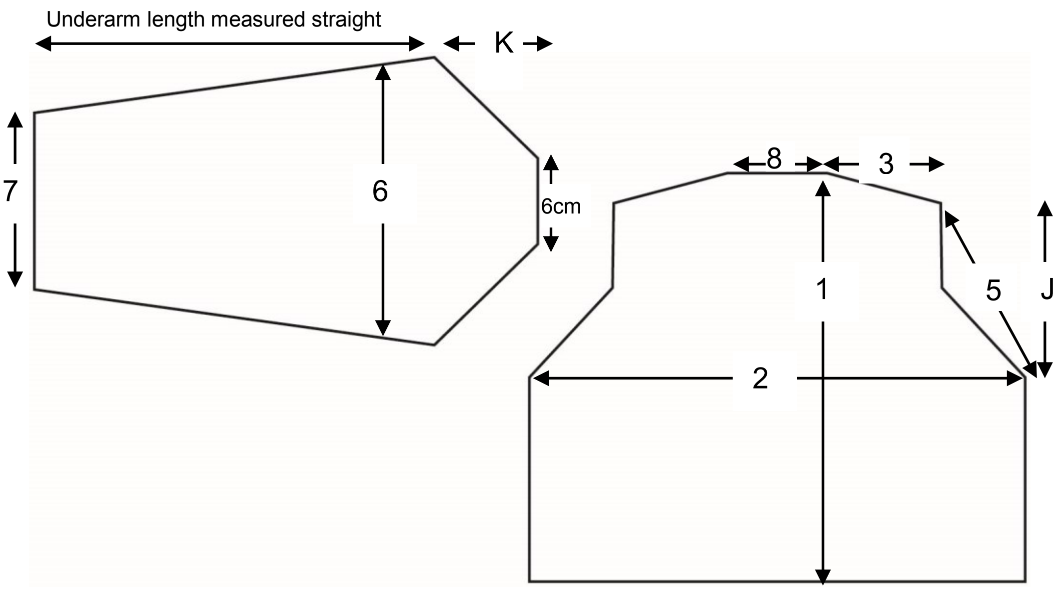


Figure 3.5 Determining garment dimension: set in sleeve (adapted from Power 2008c)

Garment dimensions that are included on the garment specification (Power 2008c)

1. Garment length
2. Garment chest
3. Garment shoulder (straight)
4. Sleeve underarm
5. Garment armhole
6. Sleeve widest
7. Cuff width
8. Garment neck width

Specification data provided to knitwear manufacturers does not include a dimension for the armhole depth, or the height of the sleeve head (Power 2008c; Kumar Puri 2010a). Both authors provide a formula for calculating the missing data using Pythagoras theorem where if any two dimensions of a triangle are known the third can be calculated. Power's (2008c) method is illustrated above (Figure 3.5) Once J is established, K is calculated as K=J-3. The 3 being half the dimension of the upper portion of the sleeve head. This method will provide a sleeve that fits the armhole, however as with Walsh (1966) there is no reference to how the specified garment dimensions have been determined in relation to the body.

Kumar Puri (2010a) acknowledges that although the underarm seam is specified, in knitting terms this is not enough information. Figure 3.6(b) illustrates why this is the case. The box indicated in blue represents the shape of the knitted panel if no shaping or fashioning (Section 3.4) has occurred. The red line indicates the underarm length which has been specified by the retail buyer. To achieve the required length fashioning must occur and therefore a calculation needs to done to establish how to achieve the finished dimension.

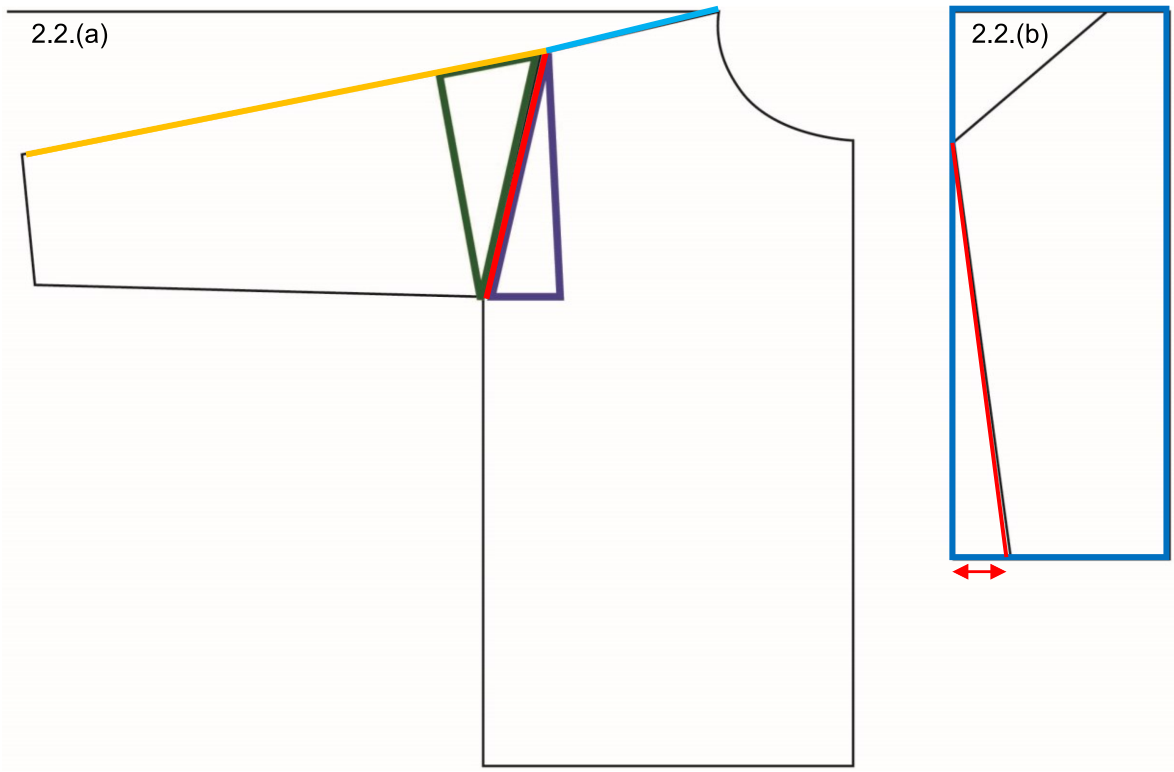


Figure 3.6 Determining garment dimension: Raglan sleeve Adapted from Kumar Puri (2010)

Kumar Puri (2008a) suggests that the angle of the shoulder slope (between the shoulder seam highlighted in purple and the shoulder to wrist line highlighted in yellow), needs to be maintained. However there is no explanation as to why this angle needs to be maintained. In woven pattern cutting there is invariably a change in this angle at the shoulder point to accommodate body curvature (Aldrich 2004). The dimension of the sleeve and armhole (highlighted in red Figure 3.6a) are calculated using trigonometry (see dark green and purple triangles).

Kumar Puri (2010a) suggests that the slope or angle of the armhole must equal that of the sleeve (highlighted in red Figure 3.6a) to prevent the adverse influence of extra fabric when linking the panels, which creates pucker. This directly conflicts with methods used for woven garment construction, where intentional manipulation of the fabric helps to create good fit. This principle is particularly important on the sleeve head which is frequently cut to a larger dimension than the armhole (Aldrich 2004), to generate 3D curvature and accommodate the shoulder and upper arm. Garments where a relatively rigid woven fabric will not allow for a full range of body movement tend to use this principle to achieve fit. The knitwear industry however does not appear to marry a sophisticated knowledge of the body, including dimensional change through movement (which is crucial at the armhole/sleeve join). Consequently it appears that garments have traditionally been constructed as flat 2D shapes. Although it is vital to acknowledge that knitted garments rely heavily on the extensibility of a knitted fabric to provide fit, a more sophisticated approach to the application of anthropometric knowledge must surely only bring benefit.

Kumar Puri (2010a) also claims that to the expert eye any distortion of stitches or knitted loops through non-alignment due to inaccuracies of panel dimensions will adversely influence the garment aesthetics. This statement indicates that knitwear experts may be using a very different set of criteria to evaluate knitted garments to those used to evaluate garment fit. There is justifiably much effort being made to achieve a garment that meets certain technical requirements. However it may be possible that these technical requirements may be limiting experimentation that could lead to new types of garment fit. In addition to this Kumar Puri (2010a) states that a garment is placed on a table to check that all the courses and wales run in straight lines and are not distorted. This type of assessment however may not necessarily relate to how the garment appears when on the body, particularly in relation to the distortion of the courses and wales.

3.4.3 Fully fashioned design limitations

Experts have argued that manufacturers producing fully fashioned garments have a tendency to be conservative regarding design development. It has been suggested that the full potential of this type of garment manufacture has not been fully exploited (Brackenbury 1992; Guy 2001) Power (2007) describes this industry sector as traditional, producing classic knitwear and further scrutiny of literature shows that there are a limited number of recognised fully fashioned styles (Mills 1965; Walsh 1966; Power and Otieno 2007; Power 2008a; Kumar Puri 2010a). These styles tend to be named in accordance with the method used to attach the sleeve to the body, such as the raglan sleeve, the set in sleeve and the saddle shoulder. The terminology used to describe fully fashioned garments styles varies, as does the number of styles identified (Table 3.1)

Power (2008) suggests that each different fully fashioned style will conform to the human form differently. This comment suggests that methods to produce these various styles of knitted garment are both well established and homogeneous throughout the knitwear industry.

Table 3.1 Fully fashioned garment styles

Author	Style 1	Style 2	Style 3	Style 4	Style 5
Walsh (1966)	Raglan sleeve	Set in sleeve			
Brackenbury (1992)	Raglan sleeve	Set in sleeve	Saddle shoulder		
Power (2008)	Raglan sleeve	Set in sleeve	Notch	Saddle shoulder	
Kumar Puri (2010)	Raglan sleeve	Set in sleeve	Straight	Saddle shoulder	Classic shoulder

Guy (2001) suggests that fully fashioned knitwear manufacturers are reluctant to escape previously established design restrictions and blamed both the lack of technical training provided for knitwear designers and the inaccurate and imprecise methods utilised in knitwear construction. This was claimed to undermine knitwear designers' ability to exploit the capabilities of the knitting machinery and result in repetitive trials to achieve satisfactory results. It was therefore proposed that knitwear manufacturers were inhibited from developing new product ranges. Eckert (2001) examined ethnographic influences on knitwear practitioners and found them to differ between the designers and the technicians. The study determined that this perceived cultural diversity was influential in a communication bottleneck within the knitwear design process, where inadequate design specifications are re-interpreted by the technicians. It was argued that tools and methods to improve the designers' ability to develop accurate specifications were needed.

3.5 Three dimensional shaping on flat-bed machinery

The shaping techniques previously reviewed suggest that fully fashioned garments tend to be two dimensional (section 3.4). However Black (2001) credited machine developments for novel integral shaping which is described as having a similar effect to a dart used in woven garments. Spencer (2001) also acknowledged that methods of 3D shaping have become easier to achieve through certain advancements in knitting machine technology.

Haffenden (2009) focussed specifically on producing three dimensionally shaped knitted garments on flat-bed machinery, for women with larger sized body shapes. Her approach was to develop custom made garments for participants who had been measured using methods designed specifically for larger women. Haffenden (2009) applied the individual body measurement to the development of the knitting patterns for each garment. This is the only account of a technique that takes a thorough and detailed account of anthropometric data and applies it to a system to define the shape of a knitted garment. However the methods used to translate body measurement data into pattern data are not documented. Haffenden (2010) mentions the use of software tools to generate knitting patterns, Shima Seiki's PGM and Knitpaint. However modifications had to be made to the patterns provided on these tools to enable a more sophisticated 3D approach to shaping. Guy (2001) also recognised the potential to create 3D shaping on knitted garments and stressed how important it is for designers to gain a better understanding of the technicalities of knitwear construction in order to improve knitwear design.

3.5.1 Techniques to create 3D shaping

Mills (1965) outlined three methods of creating 3D shaping for the bust. The first splits the front body panel into three sections at the bust region. A diamond shaped panel is knitted separately and inserted as a post-production process. The second splits the front body into three at the bust region. The edges of the three strips are fashioned to create extra width and sewn together during post-production to create 3D shaping. The final method uses fashioning to produce extra width at the selvedge. During the finishing process the side seams are straightened and bust shaping is formed. This technique suggests that the knitwear pressing process can be used to mould the garment to a required shape

A method to create vertical darts takes one centrally placed stitch and transfers it to an adjacent needle. The stitches along the rest of the row are then all transferred to their neighbouring needles until the needle that is lost is at the edge of the row. This is repeated for the number of desired courses to enable integrally narrowing to occur (Sissons 2010). Flechage or 'beret' shaping, is used to describe a technique of increasing or decreasing the course length within a knitted structure (Brackenbury 1992; Choi and Powel 2005). Haffenden (2010) used empirical knowledge to develop techniques to create 3D shape and exploited flechage to create what was described as integrally shaped suppression (or darts). A number of patents for garments have also been found that exploit the technique of flechage to create innovation (Kobata and Nakai 2001; Takimoto 2006; Kazuyoshi 2007) much of this development originates from knitting machine builders. Sissons (2010) Instructs on how to create 3D knitting effects by using partial knitting. This technique sets a given group of needles to hold position, as the carriage passes over these needles they will not knit. Varying the number of holding needles on every row enables a designer to create a variety of shapes and forms. In relation to the body, narrowing using partial knitting can create shoulder shaping, Sissons (2010) also suggests a technique of sideways partial knitting, with the wales running horizontally which can create flared shapes particularly useful for skirts and capes.

3.6 Complete garment knitting

Flat-bed knitting technology has the ability to shape fabric by combining loops adjacent to each other thereby narrowing the width of the cloth (Section 3.4) Research aiming to develop the ability to knit tubular complete garments on flat-bed machinery had been in progress since 1940, with many different commercial companies competing and collaborating (Brackenbury 1992; Hunter 2004a; Power 2007) The ability to achieve this end was clearly perceived to be commercially beneficial and a number of different methods of knitting tubular garments on two needle beds have been patented (Macqueen 1962; Robinson et al. 1967; Betts and Borrowash 1972; Bennetton 1995). Limitations with these methods however, particularly in the ability to create good quality rib, which conventionally takes two needle beds to knit prevented commercial application.

Further developments in flat-bed knitting technologies have resulted in machinery that can knit and shape three dimensionally (Choi and Powell 2005). The implication is that this technology offers the manufacturer new ways to shape and style knitted garments (Power and Otieno 2007). It is widely acknowledged that the Japanese company, Shima Seiki were the first to commercially launch this technology at ITMA in 1995 (Millington and Chapman 1989; Gibbon 1995b; Gibbon 1995a; Millington 1995; Nakashima and Karasuno 1996). Industry decline in Japan prompted Shima Seiki to introduce WholeGarment® machinery prematurely (Nakashima and Karasuno 1996), raising questions regarding the availability of specific skills and knowledge needed to exploit machine capabilities (Gibbon 1995). Perhaps this caution was justified as a report claiming that complete garment manufacture was only commercially viable five years after the initial launch of Shima Seiki's WholeGarment® technology (Mowbray 2000).

The German company Stoll are also credited with introducing important developments that enhanced commercial viability (Hunter 2004a). Millington (2000) appears to champion Stoll as the most influential machine innovators. Shima Seiki and Stoll are both acknowledged to be at the forefront of commercial application (Choi and Powell 2005).

3.6.1 Machine terminology

The machine builders have patented their complete garment technology: Shima Seiki as WholeGarment®, Stoll as Knit and Wear. Choi and Powell (2005) described the technology as three dimensional seamless garment knitting. The term seamless however is widely used to describe garments that have been knitted on Santoni circular machinery. These ‘seamless’ garments invariably require some degree of seaming, the phrase therefore is considered misleading (Siddons 2007). Troynokov’s (2008) research only uses Shima Seiki WholeGarment® technology within the methodology yet uses statistics based on products made on circular machinery to demonstrate a growing market in ‘seamfree’ products to justify the research. This is an example of a confusing use of terminology. Troynikov (2008) herself points out WholeGarment® technology requires an individual approach to garment construction because the principles for producing knitwear are so unique. It is therefore important to differentiate between garments that are made on flat-bed machinery and those made on circular machinery. Complete garment technology is commonly used in trade journals to specifically refer to Stoll and Shima machinery and therefore will be adopted for this study.

3.6.2 Shaping the complete garment

Machinery that has the ability to construct garments three dimensionally such as complete garment technology implies the possibility of creating a product that can conform to the three dimensional shape of the body. The process of shaping complete garments however will rely on machine capability. Brackenbury (1992) outlined some of the difficulties associated with knitting tubular garments on flat-bed technology, previous to many of the improvements made by Shima Seiki and Stoll. Shaping the garment is limited by the number of needles available on which to knit and transfer. An explanation of one method illustrates how development of the complete garment must be conceptualised in relation to the needle beds. The body and sleeve tubes must commence knitting on specific needles with an exact number of available needles between each tube. These needles are introduced to create underarm widening. The three tubes must meet at the correct location to merge. The sleeve tubes can then be gradually moved across and narrowed to eventually create the neck dimension. Those developing complete garments are forced to consider the development of the all the component parts of a garment simultaneously, which must surely challenge traditionally trained personnel. Troynikov (2008) did document difficulties experienced when attempting to shape the armhole and shoulder on complete garments. Three reasons were given for this: the fashioning restrictions, a lack of previous knowledge to draw on and no available garment templates or patterns on which to base methods.

Findings from literature related to fully fashioned garment construction, suggest a number of additional reasons for difficulties experienced during garment shaping: inconsistencies and inaccuracies in standard methods of shaping (Section 3.4) may influence poor results when shaping the complete garment, complex industry methods that are not fully understood and difficult to adapt to create new styles (Section 3.4), a knowledge gap regarding the application of anthropometric data (Section 3.2). Due to the relative novelty of complete garment technology no other secondary data has been found that provides specific information relating to shaping the garment. .

3.6.3 Design innovation

Numerous reports listing the potential benefits of complete garment machinery claim that machine developments will enable manufacturers to: innovate knitwear design, produce a greater variety of garment styles and influence fashion. Examples of novel design opportunities are listed as: The ability to knit a continuous pattern around the full circumference of a garment, design features such as pleats and fine gauge knitting, integral collars, pockets and flaps and multiple options to change colour and knit structure (Gibbon 1996 Gibbon 1997c; Mowbray 1999; Stoll 2000; Karasuno 2000; Mowbray 2006c; Siddons 2007; Tait 2008).

In 2002 however an interview with the president of Shima Seiki suggested that only 1% of machine capability was at the time being exploited (Mowbray 2002). Whilst this statement is making claims for a vast, untapped potential, it also acknowledges a skills and knowledge gap. The presence of a Shima Seiki design centre in Milan is clear indication of Shima Seiki's perceived urgency to provide technical support and encouragement to new complete garment manufacturers. The Japanese machine builders claimed to be constantly developing new techniques and innovative design (Mowbray 2003b). It was later claimed by Shima that through the production of 2500 new sample garments a year a whole new range of knitting techniques have been created at the sleeve, underarm, shoulder and neckline (Mowbray 2005a).

The ability to create a variety of knit structures, which provides further potential for design innovation, is also frequently mentioned (Gibbons 1995 Millington; 1998;.Karasuno 2000; Mowbray 2002)

3.7 Key dimensions

The key dimensions that define a fully fashioned knitted garment, worn on the upper portion of the body or the torso are listed by Walsh (1966), Mills (1965), Power (2008c) and Kumar Puri (2010b). These all refer to garment measurement rather than body measurement (Table 3.2 p59) It is also unclear how these measurements have been developed. The implication is that knitwear manufacturers work from previously established garment measurements, possibly generated through trial and error (Power and Otieno 2008). The garment body relationship is therefore obscured.

Troynikov (2008) looked specifically at active sportswear manufactured on machinery with complete garment capability. Her research examined the design and development process for engineering ergonomic garments. Troynikov (2008) recognised that the shape and dimensions of the product must relate to those of its wearer and to this end she tabulates a set of body dimensions and the adjustments that have been made to each of these to achieve both a fitted sports garment and a relaxed sports garment (Table 3.3). There is no explanation to guide the reader through the information on this table. The source of the measurements is therefore unknown as is the methodology used to obtain them. The garment dimensions are shown to be exactly the same as the body measurements except where there has been an adjustment. This appears to infer that the garment follows the dimensions of the body exactly. No bust girth measurement is included only a chest measurement. It is therefore likely that the garments did not include bust shaping. Column 1 of the table is a list of both body regions and garment regions such as hem. It is therefore difficult to know what this data relates to. The method used to obtain the adjustment dimensions was a set of standard fit tests on a model. Troynikov's (2008) table indicates that the degree of ease needed to achieve fit on a knitted garment can vary from a negative amount to a positive amount at differing body regions.

Table 3.2 Table of key body dimensions used in clothing manufacture (for garments that cover the upper torso only)

Author	Number of recommended key upper body dimension utilised for women's knitwear construction									Type of garment	Total No. body regions
	1	2	3	4	5	6	7	8	9		
Mills (1965)	Bust	Front waist rib	Back waist rib	Hips						Fully fashioned garments	4
Walsh (1966)	Chest width	Garment length	Sleeve width	Cuff depth	Neck depth	Back neck	Neck rib depth	Waist rib depth		Fully fashioned garments	8
Power (2008c)	Chest	Garment length	Armhole	Cuff width	Shoulder	Neck width	Widest sleeve width	Sleeve underarm		Fully fashioned	8
Kumar Puri (2010b)	Chest	Garment length	Armhole	Sleeve opening	Shoulder	Neck width	Muscle (1 inch below armhole)	Sleeve length	Shoulder slope	Fully fashioned	9
Sissons (2010)	Bust	Nape to waist	Armhole depth	Back width	Shoulder	Neck size	Arm length	Top arm	Wrist	Fully fashioned	9
Author	Number of recommended key upper body dimension utilised for women's woven garment construction									Type of garment	Total No. body regions

Table 3.3 Measurement specification documented by Troynikov (2008)

Female	Body	Adjustments	Garment	Adjustment	Garment
Height	166				
Chest	88	-3	85	2	**90**
Waist	70	0	70	2	**72**
Hem width	95	-3	92	2	**97**
Back length	55	0	55	0	**97**
Back width	35	0.5	35.5	2	**37**
Back neck drop	0.5	0	0.5	0	**0.5**
Neck width	13.5	0	13.5	0	**13.5**
Neck circumference	34	0	34	1	**35**
Shoulder width	38.5	-0.5	38	0	**38.5**
Shoulder length	14	-2	12	0	**14**
Armhole	39	0	39	1	**40**
Sleeve length	56.5	1	57.5	1	**57.5**
Sleeve bottom	17	1	18	2	**19**
Bottom diff	0	0	0	0	**0**
Collar height	4.5	0	4.5	0	**4.5**
Sleeve width 35 cm from the collar	28	-1	27	0	**28**
Back length to waist	37.5	0	37.5	0	**37.5**
Bust position from top	27	0	27	0	**27**
Front neck drop	**1.5**	**0**	**1.5**	**0**	**1.5**

3.8 Issues related to fit

The findings from prior research conducted within the field of woven garment fit. (Section 2.7 and 2.8) cannot be transferred to knitted garments as the unstable structure of a knitted fabric influences the way a knitted garment fits the body (Borrogaard 2005). It is widely recognised that two directional extensibility enables knitted fabric to mould to the three dimensional shape of a body by deformation. (Brackenbury 1992; Krzywinski et al. 2001; Moore et al. 2002). Postle (2002) uses the term biaxial extension to describe the stretch property of a knitted fabric, stressing the need for good evaluation of both biaxial and uniaxial extension (one and two way stretch). It is perhaps deceiving to use the term two directional stretch as many knitted fabrics can increase in dimension when tension is exerted across the fabric in any direction and therefore has a multidirectional extensibility (Power 2004). Power (2004) assessed deformation over a 3D form demonstrating how, unlike a woven fabric, a knitted fabric can mould around a 3D object. As a result of their ability to deform and mould, knitted garments may be manufactured using smaller measurements than the body (Krzywinski *et al.,* 2001; Moore *et al.,* 2001; Troynikov 2008). Slah et al (2006).recognise that the extensibility of a knitted fabric offers advantages to clothing manufacturers and suggests that it is one of the factors that has increased the demand for knitted clothing.

It has been suggested that knitwear has liberated bodies from the restrictive fit of the woven garment (Lewis 2007). Black (2001) also acknowledges the unrestrictive nature of knitwear claiming that historically knitted garments were worn for practical reasons including ease of movement. In the twentieth century women began to wear knitwear as outerwear and exploited its stretch properties to achieve a close, glamorous fit without sacrificing comfort. This was demonstrated by both the American sweater girls of the 1950s and the 1960s skinny-rib sweater (Black 2001; Lewis 2007). Recent studies have indicated that knitwear is becoming more fitted (Watkins 2006; Power 2007). This may present problems for knitwear manufacturers as fit discrepancies are claimed to become more tangible with tighter fit (Watkins 2006). Knitted garments, it has been claimed, will absorb dimensional inaccuracies within the stretch parameters and are therefore less likely to cause fit dissatisfaction (Honey and Olds 2007). Watkins (2006) however asserts that the Approximation of body measurement when producing stretch garments is likely to lead to fit problems such as garments that ride up or wrinkle under the arm. When reviewing literature documenting processes that determine the dimensions of fully fashioned knitwear however, little reference was made to the relationship between the knitted garment and the body. It appears that it is accepted within knitwear practice that garment fit is heavily reliant on the extensibility of a knitted fabric and not based on accurate and appropriate application of anthropometric data.

A thorough assessment of cloth extensibility has been identified as critical in order to achieve a suitable fit for the body (Moore *et al.* 2001; Troynikov 2008). Guy (2001) argues for a sound method of evaluating the properties of knitted fabrics. She also states the need for the development of methods to apply fabric analysis to knitted garment manufacture in order to consistently deliver fit satisfaction. Without such methods, Guy (2001) claims that designers will continue to over simplify the complexities involved when calculating garment specifications. This will inevitably adversely influence the fit of a knitted garment. There is currently little evidence to show how practitioners within the knitwear industry evaluate the properties of a knitted fabric in order to achieve garments that fit.

3.8.1 Fit evaluation: dimensional change through body movement

Changes in body dimension through movement must be a consideration when constructing knitted garment to satisfy fit demands. Chi and Kennon (2006) report a large degree of movement where the limbs are connected to the torso. The skin and body surface will extend or contract considerably during various periods of activity, the underarm dimension, for instance, was found to change as much as 13cm. Garments have to be constructed to accommodate these changing dimensions. The need for a better understanding of how movement affects the fit of a stretch garments has been acknowledged (Watkins 2006) yet this area of study is relatively new and there are still large knowledge gaps in how changes in body dimensions through movement can be quantified and applied to knitted garment construction.

3.8.2 Complete garment: Improved fit

In relation to knitted garments there is some consensus that they need to be considered independently to woven garments when developing and defining fit (Watkins 2006; Power and Otieno; 2008 Brownbridge 2009). In addition, this study seeks to examine the specific impact that complete garment technology has on garment fit. There have been a number of claims that this new machine capability can improve fit, firstly in specific regard to the seamless structure of the garment which is said to conform to the body more naturally then a garment made with seams (Nakashima and Karasuno 1996; Millington 2000). Secondly the improved machine capability is said to facilitate a more sophisticated approach to knitwear construction. There is little explanation to explain how the seamless structure of the garment influences fit, nor how this perceived improvement has been evaluated. In terms of the relationship between machine capability and improved fit, some specific examples have been provided. The ability to freely adjust loop length within a knitted course for instance is claimed to effectively facilitate the production of set in sleeves where there is invariably a differing number of stitches between the armhole and the sleeve. This function is also said to be able to create a more accurately shaped shoulder, which is positioned towards the back. This, it is claimed, increases the dimensional accuracy of the garment. In addition new transferring techniques are claimed to improve the capability to narrow the armhole (Karasuno 2000; Hunter

2004b). It is also claimed that complete garment technology can facilitate 3D shaping which will improve fit (Karasuno 2000; Mowbray 2005a). Section 2.6 identified a gap in knowledge regarding the application of anthropometric when developing knitted garments. Questions must therefore be raised about whether the skills and knowledge are available to exploit any potential capabilities to improve fit, which much be based on appropriate data, applied in an appropriate manner.

3.9 The UK knitwear industry

There has been some form of organised knitwear industry in the UK since the early 1400s. This early industry pre-dated mechanisation with master hand knitters forming guilds to control quality and production levels (Harvey and Compton 1978). It has been argued that demand for certain types of goods such as knitted caps, generated industry growth (Spencer 2001; Power 2007). In the early 16th century knitted stockings, a garment that had formally been produced in bias cut woven fabric, were popularised by Henry VIII's court (Black 2001; Spencer 2001). The demand for the knitted stocking provided impetus for technological developments

3.9.1 The development of the UK mechanised knitting Industry

William Lee developed a new way to knit stockings on a number of needles inserted into a frame at the end of the 16th Century, unable to obtain patronage in England, Lee travelled to France where for a short period of time he found support from Henry IV. (Gulvin 1984; Spencer 1991; Spencer 2001). After Henry was murdered Lee died in poverty in Paris (Thirsk 1989; Brackenbury 1992). Members of Williams Lee's team returned to England and a small framework knitting industry was established in London and Nottingham (Barty King 2006).

Spencer suggests that by 1750 a broad classification of the industry in the Midlands could be defined as Nottingham for cotton production, Derby for silk and Leicester for wool. Chapman however states that Nottingham had a thriving silk industry that was driven by the proximity of the Derby silk mill, this area of the East Midlands was a very important area for knitting production.

Chapman (2002) specifies four distinct periods of expansion within the knitwear industry. The first being when the knitting frame became economical at the end of the 17th century. The second was between 1758 and 1810 when technology advanced resulting in a wider array of patterning and capabilities. This enabled new types of garments to be made and generated expansion. 1815-1845 was when the factory system was adopted. Spencer (2001) documents a period of over production from 1810 which caused stagnation. A Royal charter set up in the 17th century regulated the industry in England and Wales. These restrictions have been identified as the cause of English knitters leaving and setting up business abroad, significantly Scotland (Gulvin 1984).

Gulvin's (1984) account of the history of the Scottish knitwear industry claims that after the Civil War in England in the mid 17th Century, the Scottish Parliament set up an initiative to promote a Scottish knitting industry. A thriving hand knitting industry produced stockings renowned for their superior quality (Barty King 2006). This was helpful to the immerging framework knitting industry who were able to market themselves as quality producers. In the early 19th Century factories began to be set up in the border town of Hawick. The early entrepreneurs experimented with new fibres, in particular lambswool this became a unique selling point. carding and spinning facilities also began to grow in the region. And the industry became self-sufficient. (Gulvin 1984).

The industry in Scotland was based on producing high quality woollen hosiery. However when the fashion for men's trousers was adopted, knitwear producers had to diversify their product range. In Hawick most of the producers are said to have embraced fully fashioned underwear production (Barty-King 2006). They strove to remain producers of superior products and fully fashioned garments were considered to be of a higher quality than cut and sew garments. Hawick manufacturers also began to use luxury fibres, alpaca, camel, and cashmere (Gulvin 1984). In 1910 the fashion for outerwear triggered a period of growth that lasted until 1939 (Spencer).

A recent report (Mintel 2008) stated that much of the clothing manufacture that has survived the decline since the 1990s is highly specialised niche production. The knitwear industry in the Scottish borders and the East Midlands were both mentioned as examples of this.

3.9.2 The Current UK Knitwear Industry

The UK mechanised knitting industry has a long and successful heritage and British knitters have been acknowledged to have had a global impact (Menkes 1984). Inexpensive imports have been the main threat to domestic manufacturers who have a high labour cost. The suspension of quotas set up by the multi-fibre agreement in 2005 accelerated this process (Sayer et al. 2006).

A strategy advocated for companies under threat is that of producing a value added product (Nakashima and Karasurio 1996; Karasurio 2000; Mowbray 2004b). In this way manufacturers avoid competing head to head with high volume importers, a policy which has proved to be costly to many UK companies. The closure of the Judane knitwear factory in the Shetland Isles in 2005 is just one example. Judane's policy to compete in the high volume market has been directly blamed for its failure (Bevington 2005). In comparison other knitwear companies in Shetland who have concentrated on producing high quality products have remained competitive in the global market.

A report produced for the International Labour Office in Geneva in 2000 states that during the 1980's research and technology developments concentrated on improving labour productivity and reducing manufacturing costs (Byrne 2000). This strategy however was unsuccessful in protecting the industries of developed nations and it is now thought that companies should invest in technology that will enable them to produce a superior product (Hunter 2004). Delegates at a conference held in Manchester concerned with innovation in the industry were urged by one of the industry speakers to take radical action now in order to remain competitive (Mowbray 2004). There is evidence to show that some knitwear manufacturers in the UK have invested in complete garment technology, further investigation would enable an evaluation of how this strategy had impacted on company practices and their product (Mowbray 2002; Mowbray 2005b; Quantum 2007; Hunter 2009).

3.9.3 Utilisation of Complete Garment Technology in the UK

The earliest report found regarding the utilisation of complete garment technology in the UK focusses on the development of a yarn specifically for manufacturing on Stoll, Knit and Wear machinery. The yarn development was being exploited to manufacture knitwear for golfers. The perceived advantages gained through use of the technology were described as: superior garment aesthetics, improved comfort and sizing consistency. Equally as important however was the ability to develop a completely new product range and sell directly to the consumer therefore operating a system of vertical integration (Mowbray 2004).

The central theme of an article about a Scottish luxury knitwear producer was their strategy to minimise the impact of cheap imported cashmere products (Mowbray 2005c). The primary reason for utilisation of complete garment machinery was that it enabled them to remain competitive. A long established UK knitwear company, operating a plant with a multitude of different types of knitting machinery were reported to be trialling fine gauge Shima Seiki complete garment machines. The alleviation of skills shortages in conjunction with the ability to achieve new knitwear design were perceived to be the primary advantages of implementation. The company's reputation, it was claimed, was for hand finished garments and therefore appeared reluctant to actively promote their utilisation of the machinery (Mowbray 2005b).

A UK manufacturer and supplier to the high street retailers such as Marks and Spencer, Oasis and Per Una was featured as a user of complete garment technology (Mowbray 2007). The company used 80 Shima Seiki machines which facilitated the rapid completion and deliver of orders and compete against cheaper overseas suppliers. It was claimed they were able to respond faster than anyone at the time of publication (Mowbray 2007). Good garment design was also considered to be of primary (Mowbray 2006e). The seamless aspect of the garments were thought to be of less consequence to the buyer than the potential to create an aesthetically superior product and an excellent level of comfort. The potential for medical, technical and sports applications for complete garments was also acknowledged (Mowbray 2006e).

A manufacturer based in Manchester invested in complete garment technology in 2008. (Hunter 2008d; Hunter 2008a). The managing director stated that adoption of the technology enabled the company to produce garments of a quality otherwise unachievable because of the shortage of skilled linkers. The company are a low priced, fast fashion company. One year after the implementation of complete garment technology it was reported that the investment although a risk but was a success. The garments are described as having good drape and a high comfort factor, appealing to young women in particular. The ability to be able to create different garment shapes is recognised and. they had also experienced a fall in the returns rate. The company claim that it takes less time to produce a complete garment. Productivity had increased and the ability to produce small batches in short periods of time is thought to account for this positive result.

Currently it is not possible to evaluate what impact the investment in complete garment technology will have. Reports indicate that the technology will not only influence the ability of UK manufacturers to compete successfully, but will also create changes on the garments produced. This study focusses its attention on the impact the technology has had on the utilisation of anthropometric data and the resulting garment fit.

3.10 Chapter Summary

The structure of a knitted fabric, made of intermeshed loops, has properties that have an impact on the way a knitted garment conforms to a 3D shape (Power 2004). This inevitably influences the way a knitted garment conforms to the shape of the human body. Differing knit structures have varying properties which can be exploited to create garment shape and fit satisfaction. In relation to fully fashioned knitwear a number of additional factors have been identified as influencing the creation of satisfactory fit: garment shaping relies on the manipulation of the knitted stitches on the needle beds (Mills 1965; Brackenbury 1992; Spencer 2001), a more limiting shaping method than cutting garment pieces from a length of cloth. The simultaneity of the creation of fabric and garment shaping is also an issue that must be negotiated. It is therefore justifiable to consider knitted garments separately to woven garments, in terms of the utilisation of anthropometric data (Power 2008; Power and Otieno 2008). The need to develop size charts specific to knitwear has been identified (Power 2008c). This study also identifies the lack of published information to guide on the application of anthropometric data to knitwear shaped on flat-bed machinery.

Secondary sources provided some information regarding the processes used to determine the dimensions of fully fashioned knitwear. This includes: the calculation of knit density to translate garment dimension to stitch number (Mills 1965; Walsh 1966; Power 2008c). Knowledge and experience are needed to accommodate inconsistencies of knit density within a garment and the impact of finishing processes such as pressing (Power 2008). A number of examples within the literature have been found to indicate that empirical knowledge guides the process of specifying knitted garment dimension (Walsh 1966; Power 2008; Black and Watkins 2010). Previous studies appear to focus on how to create garment shape and dimension using pre-established garment measurement (mills 1965; Walsh 1966; Spencer 2001) with no reference to its relationship with body measurement. Information relating to how anthropometric data is utilised does not appear to be available. There is in fact no evidence to explain how the fully fashioned knitwear industry utilise body measurement to develop garment measurement. There is no knitwear equivalent to the large range of literature documenting and discussing the pattern making process for woven garments. It is within the pattern making process where body measurement is applied and garment fit is determined through the addition or subtraction of ease amounts. When shaping a fully fashioned garment, it is possible to vary fashion frequency and thus create a diversity of angular and curved shapes (Power 2008c). There is therefore potential for the theory used for woven pattern construction to inform the development of fully fashioned knitwear.

Designers have been identified as being responsible for a lack of accurate specification detail (Eckert 2001). However in relation to measurement specification it appears likely that the data necessary (knitwear specific size charts) to improve knitwear designers' ability to create accurate specification documents is not currently available. Power (2008c) acknowledges that it is common practice for specification measurements for fully fashioned knitted garments to be adjusted to compensate for stretch in specific regions of the garment. There is also indication that specification documents for fully fashioned garments do not provide all the necessary measurement data needed (Power 2008c Kumar Puri 2010a), extra calculations therefore have to be made. It is evident therefore that those responsible for specifying garment measurement need to be better informed. These technical accounts also show that it is the aim of the knitwear technician to create garment panels that have all adjoining seams dimensionally equal. This contrasts with woven garment development where adjoining seams particularly armholes and sleeve heads are frequently cut to different dimensions in order to ensure satisfactory fit.

In relation to design and innovation, the fully fashioned industry has been accused of being conservative (Brackenbury 1992; Guy 2001; Power 2007). The literature review confirms that a limited number of styles are acknowledged. One of the causes for this lack of experimentation has been identified as the limited technical training that designers receive (Guy 2001). It is for instance, possible to create 3D garment shaping (Mills 1965; Spencer 2001; Haffenden 2010). If designers do not have the technical knowledge however they are unlikely to specify garments that exploit the potential to create 3D shaping. A review of patents for innovative garment design reveals that these invariably originate from the knitting machine builders rather than garment manufacturers.

Advanced flat-bed machine development has realised the potential to create commercial complete knitted garment on one machine. It has since been the subject of much speculation that knitwear designers and technicians will lack the technical knowledge to fully exploit complete garment machine capability (Gibbons 1995; Mowbray 2000). In terms of shaping Some reports suggest that complete garment technology may create limitations (Brackenbury 1992; Troynikov 2008). To create the shaping it is necessary to conceptualise the garment three dimensionally, rather than a flat panel. This is a more complex task which demands new knowledge and skills. A large number of reports have claimed that complete garment technology will enable knitwear manufacturers to increase the number of garment styles they manufacture and innovate knitwear design. Currently however there is little secondary data available to support these claims or to show that the skills to exploit machine capability are present.

The majority of sources that document the determination of shaped weft knitted garment dimension only relate to pre-established garment measurement. Only one publication has been found that relates anthropometric data to complete garment measurement data (Troynikov 2008). This document implies that exact body measurement data has been used to determine the dimensions of the garment without any adjustment prior to testing for fit. It is unknown however if this approach is experimental or based on industry practice. Sources do suggest that a dimension, equivalent to ease can be added or subtracted to body measurement when determining garment dimension (Power 2008c; Troynikov 2008). The extensibility of the fabric therefore must enable fit to be achieved even when a knitted garment is smaller than the body dimension of the wearer. The literature review also indicates that fully fashioned knitwear is constructed using very simple shapes, where the back of the garment maintains the same proportion as the front. This does not follow the same irregularities of shape and dimension as the female body and therefore provides further evidence that the fit of knitwear relies heavily on fabric properties.

No explicit information was found to explain the relationship between the properties of the knitted fabric and garment fit. The stretch properties of knitted fabrics have been credited as liberating the body (Lewis 2007) and influencing the growing popularity of close fitting, glamorous knitwear (Black 2001; Power 2007; Slah at al 2006). Watkins however warns against the over reliance of the abilities of knitwear to absorb dimensional inaccuracies within the stretch properties, stressing the importance of adopting good practice when developing fit. In relation to both fully fashioned and complete knitted garments however, the lack of data relating to the relationship between the garment and the body suggests that methods of anthropometric application may be under developed. Appropriate methods to evaluate fabric properties in relation to fit and body movement have also been identified as necessary (Guy 2001; Moore et al 2001; Watkins 2006; Troynikov 2008).

This study specifically investigates the impact that complete garment technology may have on the fit of knitwear. It identifies two factors that, it is claimed, have a positive impact on fit. The first is the seamless aspect of complete garments which are said to conform more naturally to the body. The second factor is the improved shaping capabilities which enable a more sophisticated approach. However if historically the shaped knitwear industry has ill-defined methods of creating garment shapes that relate to the body, it is unlikely that the skills and knowledge to exploit more sophisticated shaping capability is available to knitwear manufacturers.

The mechanised knitwear industry in the UK dates back to the late 16th Century and it is acknowledged to have had a global impact (Menkes 1984). There remains some evidence of traditional regional clusters where knitwear is still successfully manufactured, particularly in the Scottish borders and the East Midlands (Mintel 2008). Domestic industry however is still under threat from the huge volume of cheap imports, exacerbated by the suspension of quotas through the multi-fibre agreement of 2005 (Sayer et al. 2006). Adopting innovative technology has been advocated as a strategy to help combat this threat (Hunter 2004; Mowbray 2004) and a number of UK knitwear manufacturers have been reported to be utilising complete garment technology. These manufacturers have provided a variety of reasons to explain their decision to invest. Some of these relate directly to the garment, such as superior garment aesthetics and others that relate more to business strategy, such as the ability to operate vertical integration. This study focusses attention on the impact the utilisation of the technology has on anthropometric practices and the size, fit and shaping of the complete garment. Secondary sources offer very little evidence on which to further this specific investigation.

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Chapter 4 Methodology

4.1 Introduction

During the initial research stages, it became evident that there was a lack of published data specific to the aims of the research: The extent of utilisation of complete garment technology within the UK clothing industry, The utilisation of complete garment technology related to garment fit in the UK knitwear industries and the implied impact on product development, Current anthropometric practices regarding size, fit and shaping in the UK knitwear industry, Preferences of UK female consumers relating to size, fit and shaping of knitwear and The utilisation of anthropometric data related to complete garment technologies for the UK knitwear industry.

To develop knowledge and understanding within these areas a predominately qualitative strategy of primary data collection has been adopted. Using an inductive approach, a broad range of concepts relating to the utilisation of complete garment technology were initially explored through a review of available literature. The exploration was conducted within a technical field which uses very specific terminology and methods. It was important that the research instruments were appropriately informed to maintain credibility when conversing with participants from the knitwear industry. A critical literature review informed on general background issues and current thinking. However in the absence of relevant existing theories hypotheses were not generated. Many of the initial research concepts, such as the application of anthropometric data to clothing originate from a general field of clothing research. These concepts were refined to apply specifically to complete garment production through the collection of primary data within the knitwear industry. Conceptual categories or themes were initially extrapolated from the secondary data which provided a speculative but informed basis for further enquiry within the relevant industrial environments. The investigation focussed predominantly on human experiences and perceptions relating to the development, utilisation and evaluation of complete garment technology. In addition the garments and garment specification documents were evaluated through the application of coding categories that related predominantly to shaping methods knit structures and sizing data (Sections 4.5.7 & 4.5.8).

Grounded theory originated within the field of sociology and aims to generate new theories for new areas of research (Glaser and Strauss 1967). This study investigates within a very new field of research, the methods are loosely guided by a grounded theory strategy. Female consumer fit preferences for knitwear is in particular a very specific field of research and no literature was found to inform the methodological approach. Although research existed that related to clothing fit preferences in general, the methods used by previous researchers were found to be inappropriate for knitwear. Taking a grounded theory approach therefore was considered relevant. Each phase of the research generated a collection of key concepts, used to develop the conceptual model to achieve the final aim and generate new contribution to knowledge.

4.2 Justification of research methods

To determine the extent of utilisation of complete garment technology in the UK, the research initially complied with methods used by Power and Otieno (2008). This previous study conducted a basic mapping process to identify a sampling frame of specific weft knitting manufacturers in the UK. Power and Otieno (2008) however used only one data source (Prospect Sweetenham 2004) and only intended to sample weft fully fashioned manufacturers. To achieve the first aim of this study; data specific to complete garment technology was sought. The information in the Prospect Sweetenham report (2004) was found to be non-specific and therefore could only be used to collect background information. Therefore a strategy to collect and analyse data from multiple sources was adopted. The information generated a sampling frame for subsequent case study investigations.

Systematic scrutiny of industry journals revealed a number of speculative claims, regarding the potential benefits of complete garment technology to manufacturers, many of which originated from the machine builders. Although these journals provided an overview of industry thinking at the time of publication, they are not peer reviewed and the information was journalistic and lacking in depth. Concepts such as the ability of complete garment technology to improve garment fit for instance were vague and needed further explanation. Interviews with experts from machine builders were conducted to enable further evaluation of the utilisation of complete garment technology, related to garment fit and the implied impact on product development. In-depth information was being sought from a limited sample, (experts from the machine builders) and questionnaires were therefore considered inappropriate for this enquiry. The themes generated from the secondary data provided the framework for the semi-structured interview schedule. The semi-structured approach provided opportunities to probe for complex information combined with a systematic structure for data collection and subsequent analysis. The findings informed the research tools for the next phase of the research.

Case study research within knitwear manufacturers was conducted to evaluate current anthropometric practices regarding size, fit and shaping in the UK knitwear industry. Pitimaneeyakul et al (2004) acknowledged the lack of documentation relating to knitwear industry practices. In their investigation, which examined the knitwear product development process, they stressed the importance of studying working practices within an organisation. This approach was also considered highly appropriate to meet the research aims of this study. The themes generated from the interviews with the machine builders informed the enquiry. However as little is known about the processes involved in complete garment manufacture, a degree of exploration was required. Three strategies of primary data collection were employed during the case study research: analysis of garment specification documents, garment observations and semi-structured interviews. Face to face interviews, conducted on company premises provided an invaluable opportunity to evaluate a range of different perspectives related to the utilisation of complete garment technology. An evaluation of the product (the garment observations) provided actual evidence of garment shaping, knit structures and innovative approaches and supported the analysis of the interview data. Examination of the Garment specification documents provided additional information to support the analysis regarding garment sizing. The case study approach therefore provided data from multiple sources to inform the final analysis. Three case studies were conducted, from a sample of seven.

Previous studies exploring consumer fit preferences have tended to use questionnaires as they enable data collection from a large population and statistical analysis to be conducted. Initially therefore questionnaires were planned, to inform the development of a theoretical framework of consumer preferences relating to the size fit and shaping of knitwear. However the pilot study for the questionnaire revealed that some participants were unable to distinguish between knitted garments and woven garments, even though visual prompts were included. This indicated that self-administered questionnaires would not be appropriate to gain the necessary information on fit preferences. A more exploratory form of data collection was therefore considered necessary to probe this issue. An approach informed by grounded theory was adopted at this stage. No previous study was found to have investigated consumer fit preferences in relation to knitwear. Therefore some degree of experimentation was required when developing the methodology and tools for enquiry.

Focus groups are recommended as being appropriate to explore attitudes and opinions regarding previously un-studied research topics (Frey and Fontana 1993; Threlfall 1999). This study needed to explore not only fit preferences in relation to knitwear which had already presented problems, but also was to solicit opinions relating to complete knitted garments. The enquiry therefore focussed on a product that the participants were unlikely to be familiar with. The focus group approach enables objects (a selection of garments and fabric swatches) to be introduced to generate group discussion. Consumer perceptions and preferences were allowed to emerge within an open investigative structure, prompted by strategically selected prompts. This strategy of data collection was considered preferable to one that posed direct questions which would be problematic to develop for such an unknown area of research.

The four phases of research culminated in the development of a conceptual model for anthropometric practices and applications regarding complete garment technology for the UK women's knitwear industry. Figure 4.1 provides an overview of the research undertaken and the data collection methods utilised for each phase.

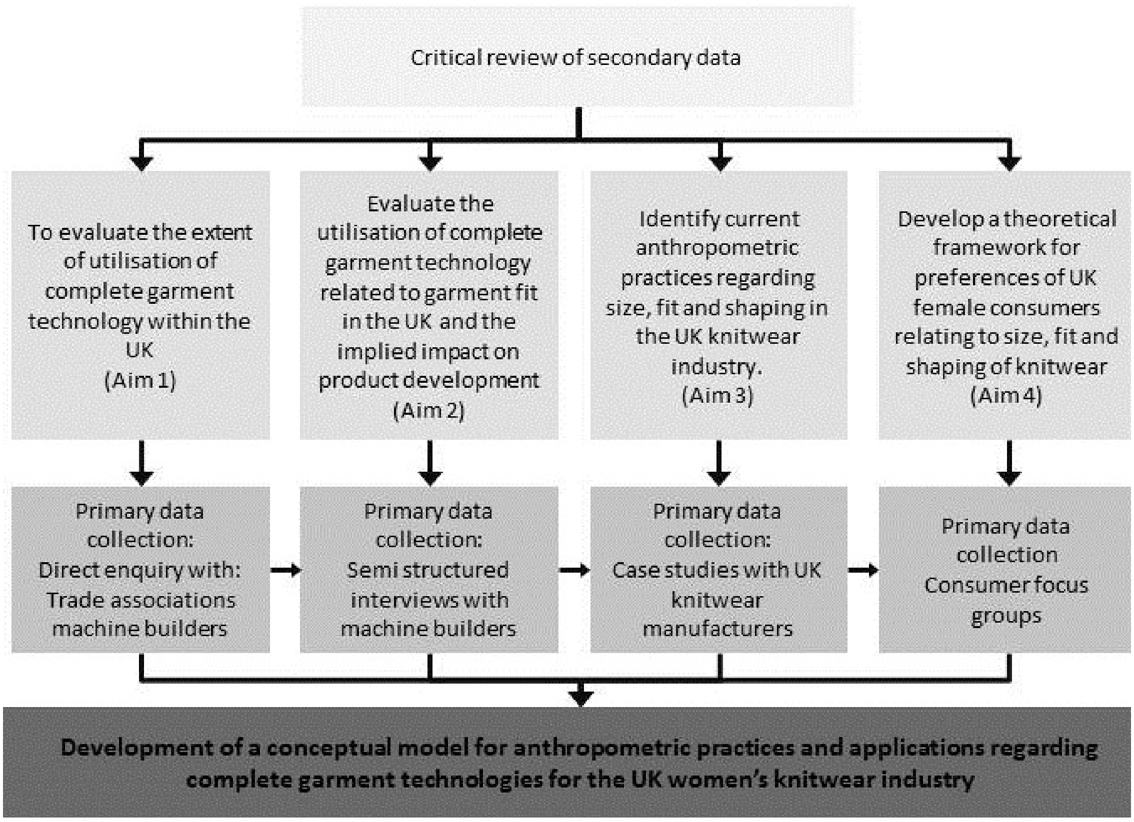


Figure 4.1 Overview of research methodology

4.3 Utilisation of complete garment technology in the UK

The initial research task was to identify the knitting machine builders leading the development of complete garment technology. Within literature key authors (Brackenbury 1992; Black 2001; Spencer 2001; Hunter 2004a) provided particularly relevant information regarding the advancements of flat-bed knitting machinery. A number of articles and journal papers identified the machine builders who have developed specific machinery (Gibbons 1995; Millington 1995; Gibbon 1996; Choi and Powell 2005; Black and Watkins 2010).

To map the UK knitwear industry data, a variety of sources were compared, cross referenced and refined. A specialist financial survey listing knitwear companies in the UK (Prospect Sweetenham 2004) was consulted, however it was found to be outdated and non-specific and consequently other sources were sought. Two electronic databases *Fame* and *Kompass* were identified as useful, both of which hold basic company information, and provided general indication of the type of product produced by a large number of UK companies.

The lists were cross referenced to include a comprehensive list of UK knitwear manufacturers. To identify the final sample frame of complete garment technology users, further company analysis was conducted. The purposive sampling technique illustrated in Figure 4.2 refined the sampling frame.

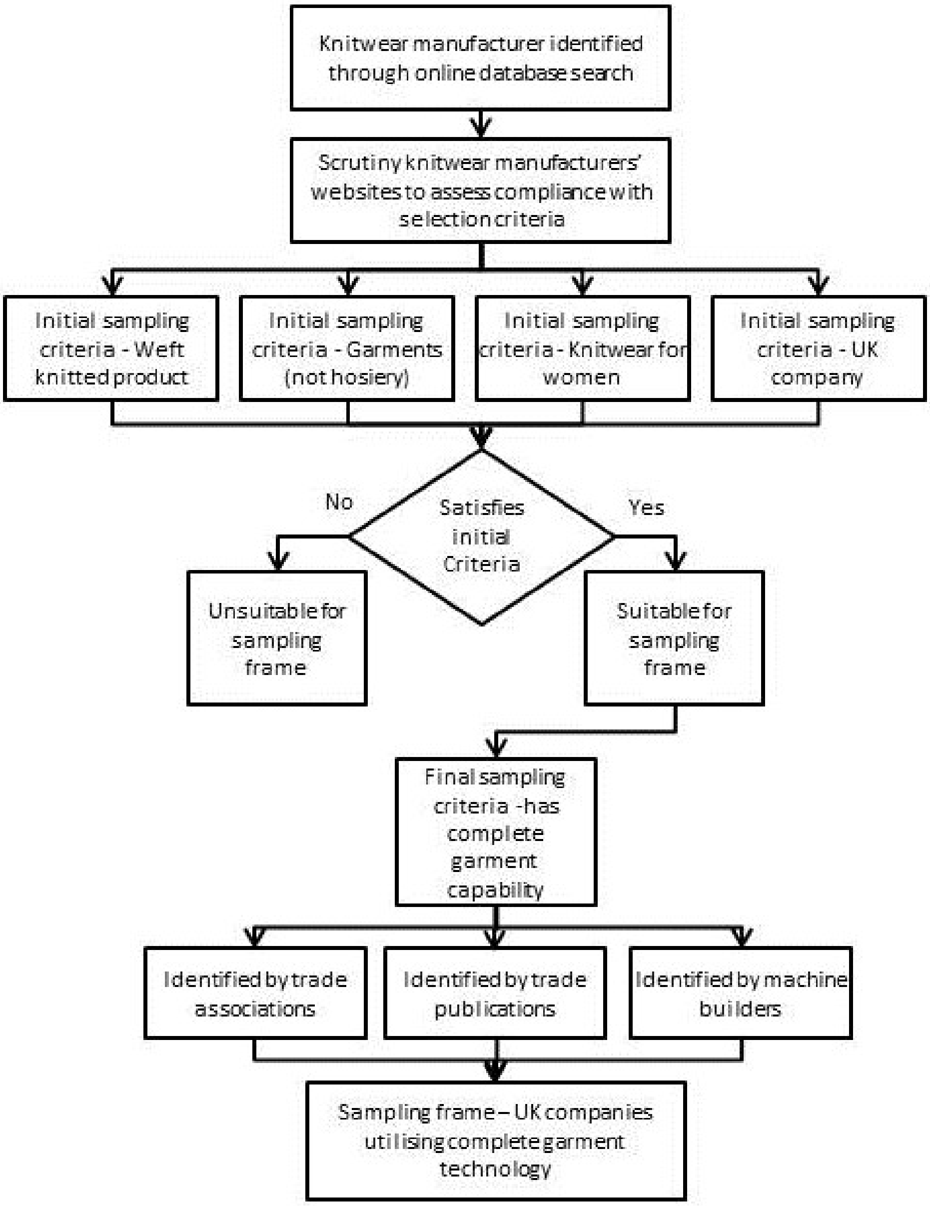


Figure 4.2 Process map to demonstrate the purposive sampling technique

To further enhance the sampling frame of potentially suitable UK manufacturers, trade journals and newspapers, located through the database *Infotrac,* were scrutinised to solicit information about utilisation of the technology. The publications, *Knitting International* and *Drapers Record* are also important sources, documenting the development of the technology and its utilisation in the UK. In addition the editor of an online resource, knittingindustry.com providing industry news was contacted to request information regarding complete garment technology in the UK (1.1.1.1Appendix C p295) Individual knitwear manufacturer's websites were found to provide more in depth information about specific knitwear manufacturers.

The penultimate stage of the process was to contact trade associations relating to the clothing industries. A web based search identified organisations within the relevant field (Table 4.1). Contact was initially established via the telephone and followed by an email requesting information on any knitwear manufacturers producing complete garments in the UK (1.1.1.1Appendix C.1 p296). Industry associations have access to large networks of companies and are therefore likely to be privy to unpublished information. Table 4.1 lists the associations who were contacted.

Table 4.1 Trade and industry guilds and associations

Trade Association or Guild	Address
The Textile Institute	1st Floor, St James's Buildings, 79 Oxford St, Manchester M1 6FQ
The Association of Suppliers to the British Clothing Industry (ASBCI)	Unit 5, 25 Square Rd, Halifax, HX1 1QG
The Worshipful Company of Framework Knitters	86 Park Drive, Upminster
British Clothing Industry Association (BCIA) (incorporating Knitting Industries Federation)	5 Portland Place London, W1B 1PW
Scottish Cashmere Association	77 Davidson Drive, Northfield, Aberdeen AB16 7QS
Scottish Cashmere Club	Not listed
Department of Business Enterprise and Regulatory and reform BERR	Ministerial Correspondence Unit, Department for Business, Enterprise & Regulatory Reform, 1 Victoria Street, London SW1H 0ET

The final stage of the mapping process was to establish contact with the complete garment machine builders. Emails were sent requesting information about companies in the UK utilising complete garment technology (1.1.1.1Appendix C.2 p301). Follow up telephone calls were also made. A data base was developed showing the results and analysis of the mapping process (Appendix C.3). The use of a broad variety of data sources resulted in the ability to perform comparative analysis and verify the findings. The final sampling frame informed the case study selection process (Aim 3)

4.4 Interviews with the machine builders: the garment

Two machine builders were identified as leading the field in the commercial development of complete garment technology (Section 4.3). The literature reviewed in relation to the innovative developments in this technology, inferred that utilisation has an impact, both on garment fit and product development processes. This second phase of the research will investigate the impact of the technology on garment fit and product development processes.

Guy (2001) acknowledged that the utilisation of novel technologies impact on knitwear design practices. In order to gain a thorough understanding of the issues from a holistic perspective, she conducted interviews with the machine builders as well as technicians and designers using the technology. Likewise, this project seeks to evaluate the expectations of those who are driving the development as they will have a unique perspective on its technical capability in relation to the knitted garment. Semi-structured interviews have been selected as the most appropriate method for data collection. Charmaz (2006) warns that interview data are not representations of reality but instead, relate to an individual's personal perceptions of reality. It is therefore important to acknowledge that the interviewees are likely to have a vested interest in promoting their own product and therefore the information may reflect some biased opinions.

Two UK representatives from each of the machine builders were interviewed face to face, on site in the UK. Two additional interviews were conducted with representatives from the headquarters of each company. It was possible to conduct a face to face interview with the German representative as he agreed to be interviewed during a conference in the UK. The interview schedule was sent via email to Japan to be self-completed by the interviewee. Although the data solicited through this method was less in depth, circumstances prevented the interview being conducted on a face to face basis. Table 4.2 outlines the interviews and the participation. For reasons of confidentiality the machine builders have been given a code; MB1 (machine builder 1) and MB2 (machine builder 2)

Table 4.2 Interviews with the machine builders: participation

Interview	Machine Manufacturer	Interviewee (position in company and code)	Interview location	Type of semi structured interview
Interview 1	MB1 MB1	UK Sales manager (MB1a) UK Technical manager (MB1b)	UK office Leicestershire	Face to face
Interview 2	MB2 MB2	UK sales director (MB2c) UK Training manager MB2e)	UK office/showroom Derbyshire UK	Face to face
Interview 3	MB1	European sales director (MB1f)	UK conference venue	Face to face
Interview 4	MB2	Japanese technical director (MB2g)	Head office, Wakayama, Japan	Self-administered through email

4.3.1 Sampling technique used to identify interviewees.

The German and Japanese machine builders MB1 and MB2, previously identified (Section 4.3) formed the sample frame from which personnel were purposively selected. The development of selection criteria for interview participation was informed by data collected from literature (Chapter 3). Figure 4.3 illustrates the purposive nature of the selection process and the selection criteria used.

The machine builders' company websites was used to establish contact details and Initial communication was established via the telephone. Conversing directly to a prospective interviewee provided the opportunity to emphasise potential advantages of the research outcomes. The interviewee selection criteria were clearly outlined to ensure access to the appropriate personnel (1.1.1.1Appendix D p299 shows the document used to prompt these telephone introductions). A snowballing selection technique was then initiated to locate representatives who could provide further in depth knowledge relating to the research aims.

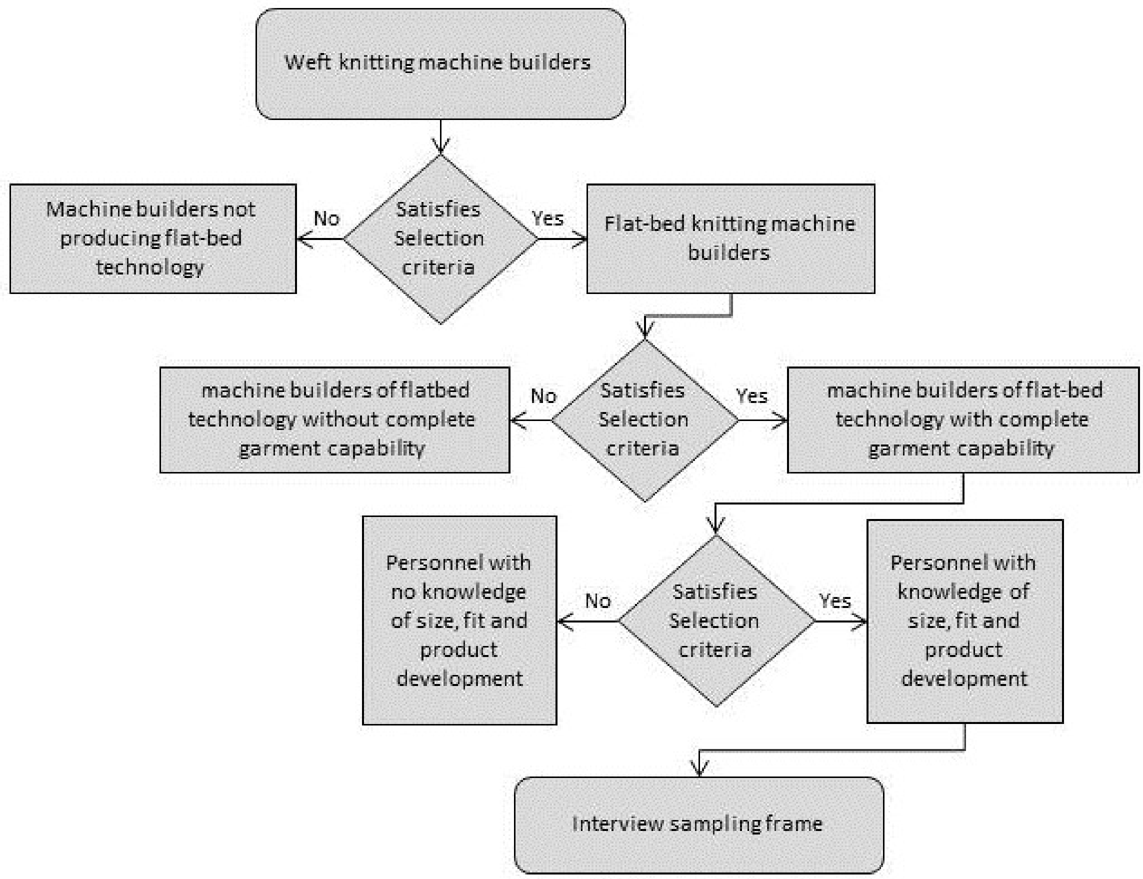


Figure 4.3 Interview selection process

4.4.1 Development of the interview schedule

To ensure that the interview questions were valid, clear and pertinent to the research aims (Saunders *et al.* 2007). Articles from trade journals prompted many points of enquiry (1.1.1.1Appendix B p289, 1.1.1.1Appendix B.1 p293, 1.1.1.1Appendix B.2 p293). Literature relating to the influence of knit properties and structures on fit also informed the development of insightful questions (Section 3.6.2

p56 & Section 3.8 p60). The interview schedule categorises seven themes that have emerged from the literature, these include:

Extent of complete garment utilisation

Customer satisfaction regarding complete garment technology

Size and fit issues

Garment shaping and design

Reduction in labour costs

Skills and training

Mass customisation

The interview will be thus divided into seven sections, each comprising of a set of questions (1.1.1.1Appendix D.1, p300).

4.4.2 Pilot interviews

Oppenheim (1992) recommends that pilot interviews should be conducted in order to identify any confusing or irrelevant questions and test the proposed time schedule. Additionally the data from the pilot interviews can be provisionally analysed to ensure the questions provoke responses relevant to the research aims. Three individuals were purposefully selected to provide differing expert feedback for the pilot study. Table 4.3 outlines the selection criteria and revisions which resulted from the pilot interviews.

Table 4.3 Selection criteria and amendments from pilot interviews

Interview subject	Area of expertise	To Advise on;	Revision to schedule
Pilot interviewee 1	Study skills support	verbal and non-verbal communication	none
Pilot interviewee 2	UK clothing industry	Advised on various industry sectors and order of questions	Clarification of questions concerning differing industry sectors. Additional question added to offer the subject a chance to add any information.
Pilot interviewee 3	Knitwear and knitting technology	Confirmed the appropriateness of the questions. Clarified the timing of the interview	none

Pilot Interviewee one advised on interview skills, communication and body language. Pilot Interviewee two had a broad general knowledge of the UK clothing industry and advised on question validity. Pilot Interviewee three had specialist knitwear and knitting technology expertise and was therefore able to assess the specifics of the interview schedule. The pilot interviewees were asked to provide feedback to enable the researcher to make necessary amendments prior to the main study. On completion of the piloting process the interview schedule was judged to clearly communicate its investigative intentions, in a manner, appropriate to the aims of the research.

4.4.3 The interviews with the machine builders

The interviews were recorded using an digital audio recorder and subsequently transcribed. The interviewees were purposively selected for their ability to contribute responses relating to the potential impact, complete garment technology has on garment fit and the product development processes (Figure 4.3 p79). Conducting the interviews on a face to face basis provided opportunity for the interviewer to probe issues of particular interest.

The interviews were developed to last between one to one and a half hours. The UK participants were asked to provide a contact name of an individual with the appropriate expertise from the head office. The interview instruments were forwarded to a UK technician from MB2 who had agreed to contact a Japanese representative meeting the selection criteria. This interview was self-administered and returned by email. The UK representatives of MB1 recommended an individual with expertise from their headquarters in Germany. It was possible to arrange a face to face interview to take place during a UK conference. Each interviewee was allocated a code that included the initial company code MB1 and a unique letter such as MB1a (Table 4.2 p78) used for transcription and the presentation of results.

4.4.4 Interview with the machine builders: Data analysis

A number of lines of enquiry were previously identified through the scrutiny of literature. These were used to develop the semi-structured interview schedules (Saunders et al., 2007). Each separate line of enquiry has been coded to relate to a key interview theme. The data from the interview transcripts were initially organised to conform to the most relevant key theme. Further analysis identified a number of secondary themes that emerged from the data. These were presented under sub headings, linked to the key themes (Chapter 6). The final stage of data analysis was conducted during the development of the conceptual model (Section 4.8). At this stage of the analysis a critical examination was conducted to identify the potential consequences of the machine builders approach to garment manufacturing techniques. Possible causal linkages between the themes were proposed, such as the link between anthropometric related knowledge and the attitude towards garment fit. This analytical technique will initiate the process of theory generation.

4.5 Anthropometric practices in the UK knitwear industry

To identify anthropometric practices in the knitwear industry, case study research, which investigates contemporary phenomena within a real life-life context (Yin 2003), was considered the most appropriate method of enquiry. The ability to utilise multiple methods of data collection, (Eisenhardt 1989), was beneficial for this investigation, as empirical knowledge held by knitwear practitioners was explored from a number of perspectives. This approach enabled data triangulation to increase the validity of the findings. Case study research has been acknowledged to be particularly appropriate for the exploration of new processes (Meyer 2001). It was therefore a pertinent choice for this phase of the investigation which aimed to identify current industry practices in relation to the utilisation of innovative technology, an area where limited knowledge is available. The study of anthropometrics in relation to knitwear manufacture is also a relatively new area of research. Although there has been extensive examination conducted by Power and Otieno (2007a; 2008b), they did not investigate complete garment manufacture. To achieve the proposed aims of this study it was necessary to probe more specifically into the utilisation of complete garment technology within the UK industry. Case studies conducted within knitwear manufacturing premises enabled a rigorous exploration of industry practices. Data collected and analysed during the literature review (Chapter 3) will generate points of enquiry for the case studies, creating simultaneity of data collection and analysis.

4.5.1 Selection from the case study sampling frame

The sampling frame of complete garment manufacturers within the UK was previously developed during the process to map the UK industry (Appendix C.3). To address the research aim to specifically investigate women's knitwear, the initial purposive selection criteria was as follows:

- Knitwear manufacturer utilising complete garment technology produced by MB1 or MB2
- Women's knitwear manufacturer
- UK manufacturer

The literature reviewed (Section 3.9.365) provided information to inform case study selection and an additional selection criteria was included.

- Knitwear manufacturer reported to be producing innovative garments through the utilisation of the complete garment technology.

Three companies were selected from the sampling frame of seven.

4.5.2 Case study development

Case studies can be conducted within one or a number of organisations (Meyer 2001). For this research project, which aims to draw general conclusions about UK industry practices, three companies will form the sampling frame. This will enable comparisons to be made when analysing the findings to identify any possible idiosyncratic results that may be specific to one company only. Key findings, common to all three companies can be considered to be more representational of the UK complete garment industry as a whole. As Meyer (2001) acknowledges there is no specific requirements of case study research and therefore methods will be adopted to specifically suit the aim. Three methods of data collection were selected:

- Semi structured interviews with purposively selected industry practitioners
- Garment observation.
- Analysis of specific company documentation.

4.5.3 Case study interviews: selection of participants

Interviews were conducted with purposefully selected personnel from the case study companies. The interviewees were required to have knowledge and experience complete garment fit, sizing, product development or anthropometric application. Table 4.4 lists the participants selected, their job roles and former experience.

Table 4.4 Selection criteria for case study interviewees

Interviewee	Employment Title	Experience
KM1des1	Design manager	Originally employed by the company that made the initial investment in complete garment technology. Employed by KM1 when they purchased this company
KM1des2	Designer	Employed at KM1 for two years. Previous experience was designing for hand flat machines in the Far East
KM1qual	Technologist (Quality control)	Previous to employment at KM1 worked on Stoll knit and Wear machinery at a manufacturer in Huddersfield.
KM1sales	Sales director	Previously employed within lingerie at KM1. Also has experience working with Shima FIRST machines at Coates Viyella.
KM1tec	Technical director	Former Shima Seiki employee. Worked on complete garment technology since 1995.
KM2des	Brand manager (design manager)	Formally employed at KM2 as a knitwear designer.
KM2tec	Design technician	Former Shima Seiki employee with majority of experience on SES flat-bed machinery
KM3sales	Retail director	Sales and marketing background in fully fashioned knitwear, managed the product development and retail stores at KM3 for 18 years
KM3tec	Knit technician	Former experience creating fully fashioned garments on Cotton frames. 12 years of programming experience. 7 of programming complete garment machinery

4.5.4 Development of the case study interview schedule

The case study interviews were semi-structured with open questions to enable participants to provide in depth answers. The interview schedule included a set number of questions, logically ordered and categorised within pre-established themes, generated from the literature review and informed by the interviews with the machine builders. Twelve themes were included (Table 4.5) (Full schedule 1.1.1.1Appendix E p305). Maintaining an organised interview structure for the all the case study interviews resulted in the generation of consistent data throughout the case study research. The data from each interviewee was therefore comparable during the analysis.

Table 4.5 Case study interview themes

Theme no.	Interview theme
1	The impact of complete garment technology on working practice
2	The impact of complete garment technology on garment sizing
3	The impact of complete garment technology on garment fit
4	Complete garment shaping
5	Product development
6	Research and development
7	Anthropometric data
8	Fit practices
9	Properties of the knitted fabric relating to size and fit
10	Machinery utilised
11	Mass customisation
12	The consumer

4.5.5 Case study interviews

To establish initial contact with the garment manufacturers, telephone calls to selected personnel were made. Snowballing methods of selection were then used to initiate contact with additional relevant participants. The interviews were conducted in the manufacturing premises of the three knitwear manufacturers. Six interviews were scheduled to be conducted, two from each company, however opportunities to interview additional participants were taken. A total of nine interviews were therefore conducted. The interviews took between one hour and one hour and 30 minutes and were recorded using audio technology and later transcribed. Each case study company was allocated an identification code to maintain anonymity. KM1, KM2 KM3 relates to Knitwear manufacturer one, two and three respectively. Each interview participant was coded according to their company code and their employment role. KM1tec indicates the interviewee was the technical director from knitwear manufacturer 1. All the information given by the respondents was audio recorded and transcribed at a later date.

4.5.6 Interview limitations

The interview with the technician at KM2 was conducted in a room where machines were running and audibility was hindered. This interviewee utilised the CAD software to demonstrate his responses which were difficult to translate through transcription. The interview questions for KM3tec were edited as the interview time had to be limited due to an excessive workload.

4.5.7 Garment observations

Garments from each of the case study companies were photographically recorded on site. The garment selection process was reliant on permission from the knitwear manufacturers and there were some issues around confidentiality, particularly for garments that were still in development at KM1. A convenience sample of garments, made available at the discretion of the knitwear manufacturers, therefore formed the basis for the observational analysis. Details from each garment including: the knit structure, the construction of the shaping, the size of the garment, the company code, the year and season, and any special garment features were recorded on a checklist. Some of the garment details were provided by personnel from case study companies. However the majority of the information on the checklist was arrived at through a critical analysis of the images at a later date. Analysis of the garments helped to contextualise the interview data and was particularly informative in regards to garment shaping. Development of the checklist was informed by the literature review (Chapter 3 p42). 1.1.1.1Appendix E.1 (p308) shows the garment observation checklist.

4.5.8 Scrutiny of company data

The database *Fame* publishes details from annual company reports, which provided some background information about each knitwear manufacturer selected for case study research. In addition, technical publications, journals, marketing information and company websites were reviewed. Requests made during the factory visits for any supporting documentation such as size specification or size charts was also made to support the data on sizing practices. Analysis of a variety of documentary evidence enhanced the case studies and provided further context to the interview and observational analysis.

4.5.9 Case study: data analysis

An initial strategy to manage the data proposed by Meyer (2001) examined all the documentation, including the transcripts, observation checklists, company documents and reports. The relevant background information for each company was tabulated to a uniform format to provide context for each case study. The case study interview data was analysed using the thematic coding system documented in Section 4.4.4 (p81). Information from the observation checklists was categorised to accord with the themes used for the interview analysis. During the initial stage of analysis, data from each case study was managed individually. Once this was completed the data as a whole was comparatively analysed (Eisenhardt 1989). Maintaining uniformity of approach and adhering to a structural format during the data analysis enhanced the comparative analysis process.

Theoretical data analysis was conducted after comparative analysis. Understanding was sought relating to: the context in which complete garment technology had impacted on the interview participants and their practices, the conditions which had created change, causal links between emerging concepts related to complete garment utilisation and the consequences that may have occurred. The emerging theory was compared and discussed with findings from the literature review. Similarities and conflicts with the existing literature were identified as were any potential indication of the emergence of new knowledge. This analysis enabled potential improvements regarding anthropometric practices within the knitwear industries to be identified. This informed the construction of the conceptual model (Section 4.8).

4.6 Development of a theoretical framework:

A theoretical framework has been described as a collection of established theories which can form a foundation to a research study (Collis and Hussey 2003; Saunders *et al.,* 2007). Blaikie (2009) suggests that this is only the case within an operational research tradition or one that takes a deductive approach. Currently there is limited published information relating to the size, fit and shaping of knitwear and subsequent consumer preferences. The development of a theoretical framework for consumer preferences related to knitwear was therefore generated through new data. Loosely guided by a grounded theory strategy the theory was allowed to emerge from the data analysis and the subsequent discussion, rather than from deduced hypotheses raised from established theory (Glaser and Strauss 1999; Charmaz 2006). Strauss and Corbin (1994), suggest that theory can be viewed as an interpretation of certain aspects of the world made from a particular perspective. Grounded theory may only be relevant for a limited time and should be seen to be subject to future expansion. The theoretical framework of UK female consumer's fit preferences related to size, fit and shaping of knitwear will aim to provide a foundation on which to base further research.

The theoretical framework was developed in three stages. Primarily the first three phases of this research (Sections 4.4, 4.5 and 4.6) generated concepts that were initially loosely defined but were refined and re-defined as the project progressed. Proposed interrelationships that existed between those concepts initiated hypotheses and theory generation (Charmaz 2006; Blaikie 2009). The relevant theory that emerged from these first three phases of the research, informed this fourth research phase and the development of the theoretical framework. Secondly, a critical review of literature was conducted to identify commonly occurring themes from previous research that related to consumer fit preferences. It is good practice when adopting a grounded theory strategy of theoretical framework development, to engage with prominent thought and acknowledge previous theoretical study (Charmaz 2006).

Originally a questionnaire was planned as the tertiary stage in the development of the theoretical framework. The questionnaire was specifically developed to gain understanding about female consumer's preferences in relation to knitwear. This strategy however was changed after the initial pilot when it became apparent that some consumers lacked the ability to distinguish between knitted and woven garments. There was also a noticeable lack of knowledge regarding specific knitting terminology, limiting the ability to communicate adequately to participants through a self-administered questionnaire. This finding directly influenced the research decision to question consumers face to face, in order to gain understanding about their perceptions relating to the terms 'knitwear', explore their ability to accurately distinguish between knitted and woven garments and interpret specific terminology (Section 4.5.1). This strategy of change and adaptation demonstrates how the data has directly influenced the research inquiry, reflecting the grounded theory approach. In addition the method of data collection was changed to a more exploratory method to solicit consumer opinion through focus group research.

4.6.1 Contextualisation of data from previous phases

The findings from phases one, two and three, provide a valuable grounding through which to identify key themes requiring exploration from the consumer's perspective. Table 4.6 outlines the themes that have been identified. These provide the basis on which to build the theory for consumer preferences regarding size, fit and shaping.

Table 4.6 Focus group themes of exploration

Awareness of issues relating to	Factors that influence purchase of	Fit preference in relation to
Ability to distinguish between knit and woven	Woven garments	Body shape
Knit structures	Knitted garments	Body image
Specific terminology	Complete knitted garments	Fabric properties, knitted and woven
Complete knitted garment		

4.6.2 Critical review of literature regarding consumer preferences

Guided by grounded theory, the literature review was conducted in order to identify current thinking and key concepts in the area of consumer preferences, particularly in relation to garment fit. The literature review contributed to the development of the focus group themes of exploration (Table 4.6). Previous academic research papers were accessed through the data bases Emerald and Scopus.

A review of methodologies used to investigate consumer fit preferences was also conducted in order to identify appropriate research instruments, sampling methods, and methodological approaches. The majority of research reviewed took a quantitative approach, utilising questionnaires to solicit opinion (C Shim *et al.,* 1991; Chun-Yoon and Jasper 1995; Anderson *et al.,* 2001; Jamal and Goode 2001; Alexander *et al.,* 2005; Lee 2005; Chatteramann and Rudd 2006; Pisut and Connell 2007). This approach enabled a large number of participants to be included in the studies, which was a key advantage. The information gained from questionnaires however is restricted and in the case of self-administered questionnaires, a technique most often adopted, it is not possible to guide participants through the process leaving room for miss-understandings and inconsistencies to occur.

A qualitative approach to soliciting consumer information is to use focus groups. Otieno (2000) used this method to gain insight into garment sizing and its role in creating satisfaction specific to children in Kenya. Grant and Graham (2005) used focus groups to investigate influencers in fashion shopping behaviour and Alexander-Connell et al. (2002) used focus groups to explore consumer attitudes to mass customisation. The former researchers acknowledged that focus groups were time consuming both in terms of administration and data analysis and therefore limited the number of participants included in the study. It was however possible to thoroughly explore research questions from a number of perspectives. Creating discussion and interaction between the participants helped to reveal the influencing factors that create opinion (Grant and Graham 2005). This was considered a key advantage for the development of theory in relation to knitwear fit preferences. To generate the relevant knowledge, an exploratory approach was considered highly appropriate for this new field of research. Alexander-Connell et al. (2002) also acknowledged that focus groups are particularly appropriate to use as an exploratory tool for new fields of study. They used focus groups to generate data on which to build a model for mass customisation for apparel. Although their aims were very different to those of this study, their chosen methodology was informative.

4.6.3 Focus Group Development

The focus groups will consist of a selected group of participants, led by a facilitator who will encourage discussion. A semi-structured approach was taken and the proceedings were conducted following a pre-determined schedule (1.1.1.1Appendix I p319). Through this medium, opinions and feelings relating to the pre-identified research themes (Table 4.6 p89) were solicited. (Collis and Hussey 2003). The focus group were able to provide in depth insight into the consumer's emotional relationship with knitted garments (Goebert and Rosenthal 2001). Utilising this method therefore resulted in a thorough exploration of the causes and consequences related to fit preferences.

4.6.4 Development of the focus group schedule

The focus groups were developed to create a social experience (Knodel 1993; Kreuger 1998b) and stimulate conversational responses. The questions were brief, used simple language and avoided introducing too many ideas or concepts simultaneously. To guide the administration of the focus groups a schedule using a format recommended by Morgan (1997) and Krueger (1998b) was developed. The decision to use a structured approach was influenced by the intention to conduct comparative data analysis. The primary stages of the focus group schedule set out to clarify the aims of the research to the participants (Krueger 1998). Procedural guidelines for the participants were also developed.

Krueger's (1998) strategy of developing six categories of questions was adopted as follows:

- The opening question provided a forum through which participants established common concerns. The question guided the participants to address a positive aspects of their relationship with clothing to encourage them to feel at ease within the focus group forum.

- Introductory questions introduced the participants to the topic of knitwear, initially comparing knitted fabric and garments to woven in order to firmly establish a distinction.
- Key questions focussed around the themes identified through the first and second stages in the development of the theoretical framework for consumer preferences (Table 4.6)
- The final stage of focus group clarified the participant's views on important issues and closed the discussion.

4.6.5 Development of focus group research instruments

Hethorn (2005) strongly advocates the use of visual prompts when soliciting focus group opinion on consumer clothing preference. This strategy was considered essential for communicating vital information to participants who lack knitwear specific knowledge. Woven garments and knitted garments were used in the pilot focus group and were found to solicit a high degree of irrelevant information. After modifications to the schedule, swatches of various knit structures and swatches of woven fabrics were introduced instead of the garments (Table 4.9 p94). Complete garments and fully fashioned shaped panel knitwear were provided by one of the case study companies and used as visual prompts.

A set of images depicting seven body shape classifications based on the FFIT classification system (Section 2.6.1 p29), was developed utilising browswear software. Two sets of images were created using the mean average bust measurements for a size 12 and a size 16, taken from 32 web based size charts, published by high street retailers (1.1.1.1Appendix I.1 p321). It was considered necessary to develop original images, as the focus group participants had found it difficult to identify with those used in the pilot study, scans of women's bodies from previous studies (Lee et al 2007). A number of prompt cards were developed 1.1.1.1Appendix I.2 p322) using themes, identified through the data analysis from the pilot focus group (Section 4.6.7 p93). This was an experimental approach and provided the participants with key words that focussed the participants' attention on the research aims. For example, a number of potential benefits sought when purchasing knitted and woven garments were provided, to prompt responses and discussion around the specific concepts that had previously emerged during the pilot focus group.

4.6.6 Focus Group Sampling

Randomly selected samples are clearly inappropriate for focus groups because the sample is not large enough to represent a population (Morgan 1997). Furthermore purposive sampling is a far more relevant technique as the focus groups will be used to enable comparative analysis of a varied population (Morgan 1997, Knodel 1993). Opinions from women with a diverse selection of body shape and sizes will be sought to explore the potential impact of knitwear industry size, fit and shaping practices. Focus group segmentation therefore will aim to create groups of women within a specified size range. This will not only enable comparison between opinions from groups of differently sized women but will also comply with the practice of using homogeneous groups as recommended by experts (Knodel 1993; Morgan 1998). It is expected that women who are grouped with others of a similar size are likely to find common ground and therefore generate free discussion.

The recommendation to maintain homogeneity amongst the focus group participants influenced the decision to limit the age of the participants within the focus groups. Ideally age will also be used as a segmentation criteria, however it is recommended that at least one focus group is conducted for each group segment (Goebert and Rosenthal 2001). The number of focus groups needing to be conducted therefore increases incrementally with the number of group segments determined. If age and size were used as two separate criteria for group segmentation the amount of focus groups conducted doubles. Comparative analysis using two variables, age and size, was judged to be overly complex resulting in an un-manageable task for the prescribed time frame. Therefore participant selection will include women within one specific age group over two specific size ranges.

The process to determine an appropriate age group was informed by case study data. Interviewees from two of the case study companies acknowledged that they sold primarily to older women in their forties and fifties. The sales director from the third case study company commented that one of their major customers targeted a consumer aged between 40 and 55 years of age. Secondary data also supports the decision to solicit information from women between 40 and 55. Recent market research (Mintel 2008) stated that in the period 2002 to 2012, the number of women aged 40-55 will have increased by 16%. Older women (40-55) are least likely to be happy with the choice of clothes on offer. This data provides good justification for studying women who fall within this demographic. As a group demographic it is growing in size. Retailers who want to increase market share therefore should be aware of their needs, particularly in relation to their dissatisfaction with current clothing provision. It is also clear that demands from this age group in terms of fashion are complex and this is likely to influence their fit preferences.

Focus group sampling criteria will utilise commonly used size coding (UK 10,12,14,16,18 etc.) as a descriptor. According to a Mintel report (2008), size 14 falls approximately mid-way in the percentage breakdown of women consumers aged between 40 and 55 in the UK (Table 4.8) and is therefore an appropriate place to make the division between the focus groups. Table 4.8 shows the group segmentation and the required number of participants

Table 4.7 Table showing sizing breakdown of UK women aged 40 - 55 (Mintel 2008)

Age	Size 8 %	Size 10 %	Size 12 %	Size 14 %	Size 16 %	Size 18 %
40-55	7	7	21	17	22	10

Table 4.8 Group segmentation

Age range of participants	Segmentation determinate	No. of participants	No. of groups conducted	Total No. of participants
40-55	UK Size 14 and under	5-6	2	10-12
	UK Size 14 and over	5-6	2	10-12
Total number of participants				20-24

4.6.7 The pilot focus group

A pilot focus group was conducted with six conveniently selected participants using the purposive sampling methods outlined in section 4.6.6 (p92). The interview was conducted in the home of the researcher in the evening. It lasted for one hour and fifty minutes and was audio recorded. Written notes were also taken by the facilitator and the seating plan was recorded to aid transcription. The participants were asked to complete a short questionnaire which provided demographic information

During the pilot focus group a number of problems were identified as follows:

- Inappropriate visual prompts caused the interviewees to be distracted which created a confused and non-specific set of responses.

- A lack of focussed discussion around fit preferences, factors of influence when purchasing garments and size issues was noted

The data from the initial stages of the focus groups which asked participants to outline factors of influence when purchasing garments was provisionally analysed using a form of descriptive statistics (Morgan 1997). This technique identified factors of influence to generate a number of key words or coding system. The transcripts were then scrutinised to assess the frequency each key word was referred to by the participants. This technique generated the prompt cards utilised during subequent focus groups proceedings. (1.1.1.1Appendix I.2 p322)

Table 4.9 lists the modifications made after identifying problems during the pilot study.

Table 4.9 pilot focus group: modifications

Problem identified in relation to visual prompts	Modification made	Problem identified in relation to a question	Modification made
Garments used when assessing the participants ability to distinguish knit from woven caused confusion	Fabric swatches introduced in preference of garments	Inappropriate and confusing question order	Fabric swatches discussed before soliciting key information
Scan images used as body shape images were too personal	Generic images created in two sizes	Questions on sizing not soliciting adequate information	Specific questions added. Cue cards added (size coding, potential factors of influence)

4.6.8 Focus group administration

Potential participants were contacted and asked to complete a short questionnaire (Appendix 4.14). These details were used to inform the segmentation of the groups. The questionnaire included an explanation of the research project without revealing any specific details that may influence group opinions. Each person contacted was asked if they could recommend other potential participants, this snowballing technique generated further recruits.

As a number of prompts were shown to the participants during the focus group, the maximum number of participants per group was restricted to six in order to facilitate effective discussion. Four focus groups were conducted over a period of six weeks. The proceedings were conducted at the home of the researcher which increased the opportunity to facilitate a social occasion. The participants were seated around a table and provided with paper, pens and a glass of water. The research aims were introduced prior to commencement and the participants were encouraged to introduce themselves. Conversation was allowed to flow freely however the facilitator urged participants to strive to maintain only one conversation at a time. Refreshments were provided at the end of each focus group.

4.6.9 Focus group data analysis

The focus groups used a number of different methods to solicit data and these required a different set of approaches to the analysis. Table 4.10 shows how each question from the focus group was analysed.

Table 4.10 Focus group methods of analysis

Analysis method	Question category	Question number
Qualitative (Grounded theory)	Opening Transition Key	1-2 8-9, 12-14 15-18, 21-23, 24-27
Keyword	Transition	3-7
Quantitative		
a) **Ranking order**	Key	11-12, 19
b) **Closed question**	Key	20

Krueger's (1998a) assumption that analysis is a process of comparison, to establish patterns, repeated information and common ground amongst the participants was acknowledged. The data analysis classified each participant within the group as a separate entity and a structured analysis which adhered to the pre-established themes to generate the initial level of coding was employed.

The software package NVivo was employed to manage the data, using 'nodes' which provide the facility to synthesise and sort the data into a number of levels. Figure 4.4 depicts an example of three levels of coding, *knitwear vanity sizing* is the primary level of coding (labelled as the parent by NVivo) and represents a key research theme. *relevance of size code* and *increased satisfaction* are secondary levels of coding and have a causal relationship with the primary code. *Recognition of retail sizing practice* and purchase preventer are tertiary level codes and have a causal relationship with the secondary codes.

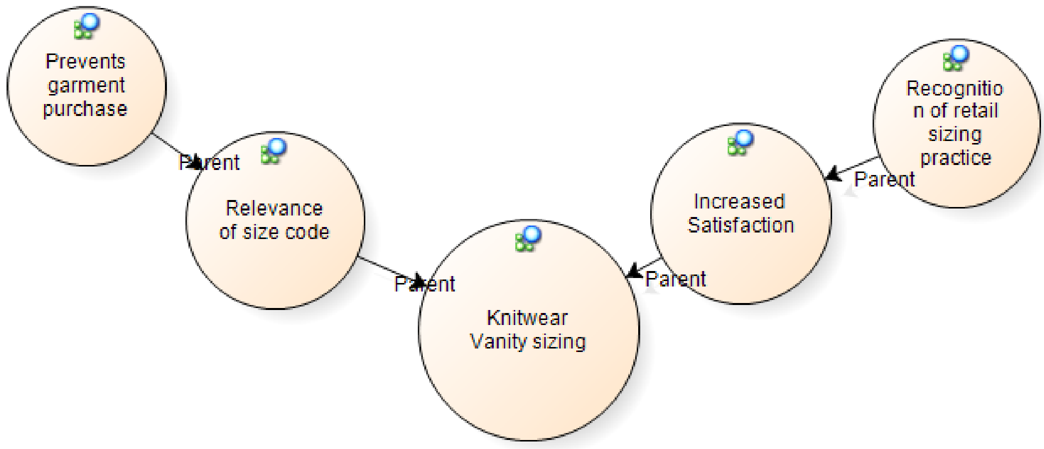


Figure 4.4 Model: Three levels of NVivo coding (vanity sizing)

Thus the data analysis organised, classified and clearly defined the concepts emerging from the focus group data. The interrelationships between these concepts were applied and critically discussed within the wider context of established consumer fit preference theory generating the new theoretical framework relating specifically to knitwear.

4.7 Research Ethics

A number of ethical issues were considered throughout the research project outlined below.

- The aims of the research were clearly outlined to all the research participants prior to data collection throughout all the phases of the research. Emails will be sent prior to any verbal communication and these will always explain why the information is needed.
- Issues concerning the use of sensitive commercial information were addressed. Each participant was asked to sign an agreement form to state that the information they had supplied could be published within the thesis. Participant anonymity has been maintained within the thesis.
- The participants were be asked to grant permission for the interviews to be recorded and the recorder was placed in an accessible position so it could be paused easily if requested.
- The risk to the researcher's and participants' safety when conducting the interviews, case study observations and focus groups was minimised by informing the University by email when and where each interview was conducted. A risk assessment form was completed for each interview.

- The focus groups addressed issues relating to the participants' bodies. The participants were all briefed during the introductory stage of the focus group and it was explained that they could withdraw from the discussion at any point. A de-briefing at the end of the proceedings provided time to specifically address any issues that may have occurred.
- During the focus group recruitment stage sensitivity around body size issues was addressed and participants were asked to self-select their size.

4.7.1 Validity

4.8 Development of a conceptual model: Phase five

It is suggested that research projects are built on concepts which are ideas that can be expressed in words or as symbols (Blaikie 2009). Earn and Ennett (1991) propose that variables and factors are just different terms for concepts. The term variable however is more often used within quantitative research. Concepts have also been defined as abstractions of a portion of reality (Guizardi 2005). Models can provide a conceptual or theoretical framework and organise results (Blaikie 2009). Conceptual models can be pictures, diagrams or intellectualised descriptions proposing a set of interrelated guesses about a part of the whole world (Lave and March 1975; Kotiadis and Robinson 2008; Wilson 2001). For the purposes of this research the proposed conceptual model has been defined as a diagrammatic description showing the relationships between the concepts that emerged during the completion of aims one to four. The conceptualisation described within the model was naturally integral to the utilisation of anthropometric data regarding complete garment technologies for the UK women's knitwear industry.

It has previously been acknowledged that when using grounded theory, concepts originally loosely defined, become refined as the research progresses. Adopting an ontological approach, which aims to identify the character of phenomena and outline the relationships between the concepts, is advocated by a number of conceptual modellers (Guizardi 2005). Identifying the more common or more important concepts within the conceptual model will be a priority (Shanks et al 2003).

The development of the conceptual model will also be guided by that developed by social scientists Lave and March (1993), who suggest taking a four step process consisting of: Observation (consequences), speculation (implication), deduction (predictions) and evaluation. The development process will be iterative through a cycle of model construction, evaluation, rejection and reconstruction (Figure 4.5).

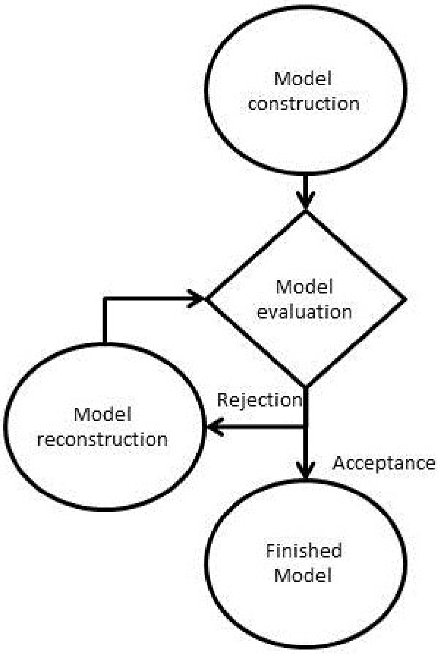


Figure 4.5 Model construction process

The initial stage of building the conceptual model will be to scrutinise the data collected at phases 1-4 of the research. Patterns within the data will be noted and speculations about the causes of these patterns will be proposed. An example of this process might be to identify that knitwear companies utilising complete garment technology produce garments with no bust, waist or hip suppression. A speculative cause of this might be that the skills and experiences of those responsible for garment development are based on knowledge transferred from using different knitting technology, which limits the ability to understand how to create body suppression shaping. The next stage of this process is to recognise other implications that would exist if this model was correct. One implication might be that complete garment technology would require new skills and knowledge in order to successfully exploit the possibility to create garments that are shaped three dimensionally to replicate the female body. This proposal will then be examined and compared to other findings, triangulating the data. Thus model development actively questions the assumptions and conclusions formed through all the phases of the research. The conceptual model will start as speculative and be developed through an explicit documentation of the process of questioning, evaluation and rejection.

Particularly relevant to the proposed research project is the claim that a conceptual model can be informed by more than one theory and can represent empirical findings or the experience of practicing professionals (Earn and Ennett 1991). The conceptual model for the utilisation of anthropometric data for complete garment technologies provides explanations for underlying associations between the concepts, made explicit within the conceptual diagram by using arrows to show directionality. The final conceptual model will be an edited version that shows the causal relationships between only the most important concepts. It will utilise defined modelling language to clearly define the key concepts and their sub categories. The aim will be to construct a diagrammatic representation that effectively explains the emerging theories discovered throughout the research processes.

4.9 Chapter summary

This chapter has documented the methodological approach proposed to achieve each of the research aims. A qualitative, strategy, informed by grounded theory has been outlined, stressing the importance of building theory where currently very little data exists. This adopted strategy will focus on listening and observing, in an open manner free of pre-conceived ideas to gain deep understanding of practical experience, rather than seeking scientific proof. It will primarily be a study of empirical events. Various methods of data collection: scrutiny of documents, semi structured interviews, observations and focus groups have been selected to achieve the research aims. The chapter has documented the plan of execution for each of these research methods in relation to each specific research aim.

The strategy for the first phase of the study, to identify of the extent of the utilisation of complete garment technology within the UK clothing industry has been outlined (Section 4.3 p75). As the research is to be conducted within the UK knitwear industry this initial research phase will help to establish and define the current knitwear industry in the UK, particularly with regards to complete garment technology and its utilisation. Focus has been directed at locating and collecting data from a variety of sources to firstly identify the machine building companies who have developed complete garment capability and secondly map the UK knitwear industry. This mapping process will be used to determine which UK companies have invested in complete garment technology and will therefore be included in the sampling frame of case study companies, utilised in phase three of the study. On completion of this initial research phase the number of knitwear manufacturers in the UK who have invested in complete garment technology will be established. However no insight into the factors that have influenced or inhibited knitwear manufacturers to invest in complete garment technology will have been gained. Nor will any understanding have been developed regarding the impact the technology may have on knitwear manufacturers.

Section 4.4 (p77), documents the strategy to achieve the second research aim which will evaluate the utilisation of complete garment technology related to garment fit and its implied impact on product development. The enquiry will focus on the perspective of the machine builders who have developed complete garment capability, previously identified during phase one of the research. An extensive literature review revealed very little theory relating specifically to the research aim. However a large number of speculative claims regarding the potential capability of complete garment technology and its consequential impact were found in trade journals. These generated a considerable number of research questions, which informed the semi structured interviews. Following a grounded theory approach the data from the interviews was collected and analysed to generate further research questions regarding anthropometric practices regarding size, fit and shaping in the UK industry. This formed the basis for the third phase of the research, documented in Section 4.5 (p81). This third phase employed case study research conducted with three UK knitwear manufacturers, previously identified as utilising complete garment technology (Section 4.2). Semi structured interviews, observations and scrutiny of company documents relative to the research enquiry were conducted. Data collection and analysis ran concurrently.

The fourth phase of investigation to determine female consumer fit preferences in relation to knitwear is documented in Section 4.6 (p87). Data analysis from phase three informed the decision to target female consumers aged between 40 and 55. As with all the other phases of this research; consumer preference in relation to the size, fit and shaping of knitted garments is a field of research that remains very much un-documented. Complete garments can be classified as a sub category of knitted garments. The commercial existence of this sub category of knitwear is relatively recent. Data analysis from phase two and three of the research found that exploration is required to gain knowledge and understanding about consumers' perceptions relating to these innovative garments. The original plan to take a quantitative approach for this final phase of the research was modified, after analysis of the data from the pilot questionnaire. Gaps in consumer knowledge were identified which would be likely to jeopardise effective communication during self-administered questionnaires. It was considered appropriate, in line with grounded theory guidelines, to base a new line of enquiry on this finding. Therefore a face to face exploratory data collection method was considered to be more appropriate to probe consumer's preferences in relation to knitwear. Four focus groups were conducted to solicit information from female consumers aged between 40 and 55 regarding size, fit and shaping preferences. Focus groups provided a forum where consumers' reactions to prompts were observed. Within this forum, it was possible to use verbal prompts to ascertain whether the participants fully understood the questions.

Section 4.8 (p97) explains how a conceptual model will be developed to explicitly depict the relationships between the concepts previously identified during the completion of aims one to four. The model development will provide an opportunity to synthesise and analyse the research findings holistically. It will enable Insightful conclusions to be drawn and contributions to knowledge will be made through explication of issues, relating to the utilisation of anthropometric data for complete garment technologies within the UK women's knitwear industry.

Chapter 5 Findings: Mapping the UK Knitwear Industry

5.1 Introduction

The first aim of the research was an investigation to examine the extent of the utilisation of complete garment technology in the UK knitwear industry. This was achieved through a five stage plan involving various sources of data collection and analysis. The purpose of stage one was to determine the sample frame for the interviews with the key machine builders. Secondary literature was scrutinised in order to identify those companies who are commercially producing machinery capable of manufacturing complete garments. Stages two, three, four and five all involved data collection to inform the sample frame for the case studies and determine the extent of utilisation in the UK. Initially, relevant industry data bases (Kompass and Fame) were consulted in an attempt to evaluate the UK knitwear market in relation to complete garment manufacture (stage 2). This was enhanced by contacting key stakeholders within the industry with requests for relevant information. Links to Industry and trade associations were established to initiate a snowballing effect (stage four). The complete garment machine builders identified in stage one were contacted (stage five). Throughout phase one appropriate and current literature was examined and any additional UK knitwear manufacturers that fulfilled the criteria were added to the final sample frame (stage 3).

5.2 Stage one: identification of key machine builders.

The investigation into worldwide knitting machine manufacturers found that there are in the region of eighteen leading companies producing flat knitting machinery (Curtis 2008) Table 5.1 illustrates the sample frame and lists the machines that have are marketed as having complete garment capability. Only two companies were found to produce machinery specifically marketed for complete garment production (Spencer 1991; Nakashima and Karasuno 1995; Gibbon 1996; Nakashima and Karasuno 1996). Shima Seiki are widely acknowledged as the first machine building company to introduce the technology commercially in 1995 (Gibbon 1995b; Gibbon 1995a; Spencer 2001; Hunter 2004a). Stoll are also credited as market leaders through the introduction of developments that enhanced the commercial viability of the machinery (Hunter 2004a; Choi and Powell 2005; Mowbray 2006c; Power 2007).

Table 5.1 Sampling frame of flat-bed machine builders

Machine building company	Company head office	Machines with Complete Garment Capability
A.P.M.	Via Mavora 15, I-40019 S. Agata Bologonese (BO) Italy. Phone: +39 051 956176 Fax: +39 051 957917	No
Armi srl (Scomar)	via Rocca tedalda 25, I-50135 Firenze Italy. Phone: +39 055 6503766 Fax: +39 055 6503706	No
H. Stoll GmbH & Co.KG	Stollweg 1, D-72760 Reutlingen Germany. Phone: +49 7121 3130 Fax: +49 7121 313110	CMS 740 S knit&wear CMS 822 S knit&wear CMS 730 T knit&wear CMS 830 C knit&wear CMS 730 S knit&wear
Intercontinental srl	via Cavour 380, I-41030 Ponte Motta Di Cavezzo (MO) Italy. Phone: +39 0535 58947 Fax: +39 0535 58459	No
JY Leh Industrial Co. Ltd.	35 Ho Din Road, Pan Chiao City Taipei Hsien Taiwan. Phone: +886 2 29578837 Fax: +886 2 29524259	No
Kauo Heng Precision Machinery Ind. Co Ltd.	No. 20, Lane 14, Ho Ping Road, Panchiao Taipeil Taiwan. Phone: +886 2 2955 9258 Fax: +886 2 2962 9153	No
Le Sanho Machinery Co. Ltd.	273 San Chun Street, Shu-Lin Taipeil 23805 Taiwan. Phone: +886 2 2688 2454 Fax: +886 2 2688 9091	No
Matsuya Corporation	6-1 Takane, Satomachi, Anjo Aichi 446 0001 Japan. Phone: +81 566 979441 Fax: +81 566 986072	No
Nuova Rimach srl	via XXV Aprile 85/87, I-25038 Rovato (BS) Italy. Phone: +39 030 7716711 Fax: +39 030 7703153	No
Omega srl	via Roma 171, I-40041 Gaggio Montano (BO) Italy. Phone: +39 0534 37002 Fax: +39 0534 37573	No
Protti Fashiontronix SpA	via Favaglie S. Rocco 4, I-20010 Cornaredo (NI) Italy. Phone: +39 02 936141 Fax: +39 02 93614902	No
Sheng Meei - Flying Tiger	Chung Chen Road, 241 Lu Chou City Taipei Taiwan. Phone: +886 2 2281 0251 Fax: +886 2 2281 3034	No
Shima Seiki Mfg. Ltd.	85 Sakata, 641-8511 Wakayama Japan. Phone: +81 73 4748210 Fax: +81 73 4748270	SWG-X WholeGarment NewSWG-V WholeGarment NewSES-V.WG WholeGarment NewSES-C.WG WholeGarment SWG041/061N/091N WholeGarment
Sisma SpA	via Piemonte 4 Z.I., CP 304 I-36015 Schio (VI) Italy. Phone: +39 0445 595511 Fax: +39 0445 595 595	No
Sangyong Machine Ind. Co Ltd.	No 168-27 Wha Yang-Dong, Seung Dong-Ku Seoul Korea. Phone: +82 464 71415 Fax: +82 467 7799	No
Steiger SA	Route du Simplon 20, Case Postale CH-1895 Vionnaz Switzerland. Phone: +41 24 4822250 Fax: +41 24 4822278	No
Technotex srl	via G Bruno 34, I-47014 Meldola (FO) Italy. Phone: +39 0543 495179 Fax: +39 0543 495179	No
Universal Stricksysteme Vertriebs GmbH	Deutschordenstrasse 38, D-73463 Westhausen Germany. Phone: +49 7363 880 Fax: +49 7363 88202	No

5.3 Stage Two: Development of case study sampling frame

To determine the sampling frame for the case studies, a specialist financial survey listing knitwear companies in the UK (Prospect Sweetenham 2004) was initially consulted but although a list of manufacturers were provided, the information was outdated and not specific in relation to the type of knitwear manufactured. Consequently other sources were sought, keyword searches were conducted to locate UK companies within the Kompass database. No results were found in response to the enquiry for weft knitter, whole garment or complete garment. 144 companies were identified as a response to entering seamless as a key word on the search facility, however none of these companies were found to be knitwear related.

Fame utilises Standard Industrial Classification (SIC) codes to categorise companies listed on its database. Table 5.2 shows the results when a search was conducted using primary SIC codes.

Table 5.2 Results of primary SIC code search in Fame

Primary SIC code	Classification	No. of companies found
SIC 17	Manufacture of textiles	5909
SIC 18	Manufacture of wearing apparel, dressing and dyeing fur	5902

The initial search was too general and therefore too large a sampling frame resulted. Further exploration of the search tools on Fame revealed the ability to use secondary SIC codes providing a more specific result.

Table 5.3 Results from secondary SIC code search in Fame

Secondary SIC code	Classification	No. of companies found
SIC 177	Manufacture of knitted and crocheted articles	**43**
SIC 1772	Manufacture of knitted or crocheted pullovers, cardigans and similar articles	**37**
Total suitable for the sample frame		**54**

The combined searches from Kompass and Fame revealed a total of 124 companies. Some of the companies were listed on both data bases, a cross referencing process resulted in the number of companies reducing to 116 (Appendix 4.1 companies entered in black). **Error! Reference source not found.**, Table 5.2 & Table 5.3 all show that it was not possible to access specific data about companies utilising complete garment technology through Kompass or Fame. The information provided by these databases is limited. It included the number of employees and some information on financial turnover, which helped to form an assessment regarding each company's ability to afford the necessary investment to enable the purchase expensive new technology. A brief description of the product was listed for some of the companies, but this was found to be incorrect in some cases and was insufficient to determine accurately which company met the case study selection criteria (Section 4.5.1 p82). Stages 3, 4 and 5 of the research were therefore necessary to collect further data to inform the case study sample and complete aim 1.

5.4 Stage three: Development through literature review.

It was identified through the literature review that five companies in the UK were utilising complete garment manufacture (Mowbray 2004; Mowbray 2005b; Mowbray 2005c; Mowbray 2006a; Mowbray 2007; Hunter 2008b; Hunter 2008a). Four of these companies were already in the sampling frame (highlighted in orange Appendix C.3 column B and L). Details of the new company were added to the data base. (Appendix C.3 highlighted in brown Column B and L).

5.5 Stage four: Development through snowballing strategy.

The Textiles Institute and The Association of Suppliers to the British Clothing Industry (ASBCI) were identified through their activities involving universities and academic research. It was therefore possible to establish contact through pre-existing links with Manchester Metropolitan University. Initial telephone contact was established, in order to create a personal relationship. Emails were then sent out requesting information regarding UK companies utilising complete garment technology. The ASBCI were unable to provide any details about knitwear companies as their membership does not include UK knitwear producers. They provided the contact details of a representative of Stoll and one other contact from Nottingham Trent University who they thought could help. The textiles Institute did not provide any information although several follow up emails and telephone calls were made. Other associations were found through online searches and emails were sent requesting information. Table 5.4 shows the trade associations contacted, the method through which they were identified and the results from the enquiries.

Table 5.4 Results from trade association enquiries

Trade/Industry Association/Guild	Method of identification	Result
The Textiles Institute	Links with Manchester Metropolitan University.	No manufacturers utilising complete garment technology identified, however an independent contact was supplied who suggested three companies: Two were found to be no longer trading
The Association of suppliers to the British Clothing Industry (ASBCI)	Links with Manchester Metropolitan University	No Knitwear manufacturers utilising complete garment technology identified
The Worshipful Company of Framework Knitters	Address found through an online search	Contact details for 3 complate garment manufacturers
British Clothing Industry Association (BCIA) (incorporating Knitting Industries Federation)	Address found through an online search	No Knitwear manufacturers utilising complete garment technology identified
Scottish Cashmere Association	Address found through an online search	No Knitwear manufacturers utilising complete garment technology identified
Scottish Cashmere Club	Address found through an online search	No Knitwear manufacturers utilising complete garment technology identified
Department of Business Enterprise and Regulatory and reform BERR	Address found through an online search	No Knitwear manufacturers utilising complete garment technology identified

5.6 Stage five: Further development of the case study sampling frame

Requests were made to the machine builders for information on the utilisation of complete garment technology (chapter 3.1.5). An initial telephone conversation with a representative from Shima Seiki resulted in four named UK companies being provided, three of which had previously been identified as suitable for the case study selection. The fourth contact provided by Shima Seiki had been previously been recognised as utilising complete garment technology for accessories. It remained unclear however whether this manufacturer utilised the machinery to produce complete garments. The sampling frame was updated to include this information (Appendix C.3 highlighted in blue column L). Although it was agreed that the contact from Shima Seiki would respond in writing supplying details of UK companies manufacturing complete garments this confirmation was never received. Attempts to collect information from Stoll were unsuccessful. Telephone calls and emails remained unanswered. An email sent directly to the Stoll contact (provided by one of the trade associations) was answered, stating that the sales team were reluctant to breach customer confidentiality.

5.7 Final development of the case study sample frame

The final sampling frame used to inform the case study selection is illustrated in Appendix C.3. 116 companies were originally identified through data base analysis The geographical location of these companies are shown as black circles in Figure 5.1 (p109). Stage 3 identified 4 companies who were suitable for case study selection (3 of these are indicated as orange circles in Figure 5.1). One of these companies was not previously entered on the data base and was added (Appendix C.3 column B row 66 updated in brown) (Indicated as a dark red circle in Figure 5.1). Stages 4 and 5 did not reveal any new data, however at stage 4 two sources identified three of the companies previously found at stages three as suitable for case study selection. At stage 5 one of the machine builders identified four of the companies found during stage 3 as suitable for case study selection. The sampling frame at this point consisted of 117 companies. In addition to the data found through the searches conducted in Fame and Kompass several regional online directories with listings of knitwear companies were found through online search engines. The sampling frame database was updated to include the findings from these (Appendix C.3, column B updated in green) (Indicated as green circles in Figure 5.1). This brought the total number of companies to 147. Two articles found on an online trade magazine ‘knittingindustry.com’ identified two UK manufacturers who have recently invested in complete garment technology and therefore suitable for case study selection (Appendix C.3, column B and L updated in purple). This online resource also confirmed that the company identified as having complete garment accessory machines also have machines with complete garment capability (Appendix C.3, row 90 column B and L updated in purple) (The three additional companies are indicated as purple circles in Figure 5.1). This new data brought the total number of knitwear manufacturers meeting case study selection criteria to seven. The editor of knittingindustry.com was contacted through email requesting details of knitwear manufacturers utilising complete garment machinery. Five companies were identified all of whom had previously been found during prior stages (Appendix C.3 column L updated in yellow). The information on the data base at this was still insufficient to categorically determine whether any more than seven companies were suitable for case study selection. Therefore additional online searches were conducted in order to gather data to inform the final sample. Scrutiny of Individual company websites enabled collection of information such as product details. These were highlighted in pink column K and P, in appendix C.3. This information was used to determine which companies in the data base met the selection criteria

(Section 4.5.1 p82). The results are found in column M appendix C.3 and summarised in Table 5.5.

Table 5.5 Database analysis: case study suitability

suitable for case study selection	Unsuitable for case study selection	suitability unknown	unlikely to be suitable	Total number of companies
7	*47*	*51*	*42*	*147*

Table 5.6 Summarises the mapping process, listing each company found to be suitable for inclusion in the case study sampling and the number of sources of identification.

Table 5.6 Case study sampling frame

Knitwear manufacturers utilising complete garment technology (Case study sampling frame)		**No. of sources of identification**	**Source of Identification**	**Machine supplier**
Name	**Address**			
B S Attwall	14-20 Cannock St, Leicester, LE4 9HR	**3**	Article in Knittingindustry.com Email from editor of knittingindustry.com Telephone conversation with machine builder	MB2
Glenbrae high performance knitwear (Trade name, owned by Spectrum yarns)	Spa mill, New St, Slaithwaite, Huddersfield, West Yorkshire,HD7 5BB	**2**	Article in Knitting international Email from editor of knittingindustry.com	MB1 & MB2
Hawick cashmere company Ltd	Trinity Mills, Duke St, Hawick, Borders, TD9 9QA	**3**	Article in Knitting International Email from editor of knittingindustry.com Telephone conversation with machine builder	MB2
John Smedley	Lea Mills, Leabridge, Matlock, Derbyshire, DE4 5AG	**4**	Article in Knitting International Email from Billy Hunter editor of knittingindustry.com Email from the Under Warden, Worshipful Company of Framework Knitters	MB2
James Johnston & Co. of Elgin Ltd	Newmill, Elgin, IV30 4AF (knitwear production in Hawick)	**3**	Article in knitting international Telephone conversation with machine builder Article in knittingindustry.com	MB2
Quantum Knitwear Ltd	North St, Huthwaite, Nottinghamshire, NG17 2PE	**5**	Articles in Knitting International Email from editor of knittingindustry.com Email from Nottingham Trent University (Contact through ASBCI) Email form Under Warden, Worshipful Company of Framework Knitters Telephone conversation with machine builder	MB2
Viva knitwear	12-14 midland St, Manchester, M12 6LB	**2**	Article in knittingindustry.com Email from editor of knittingindustry.com	MB2

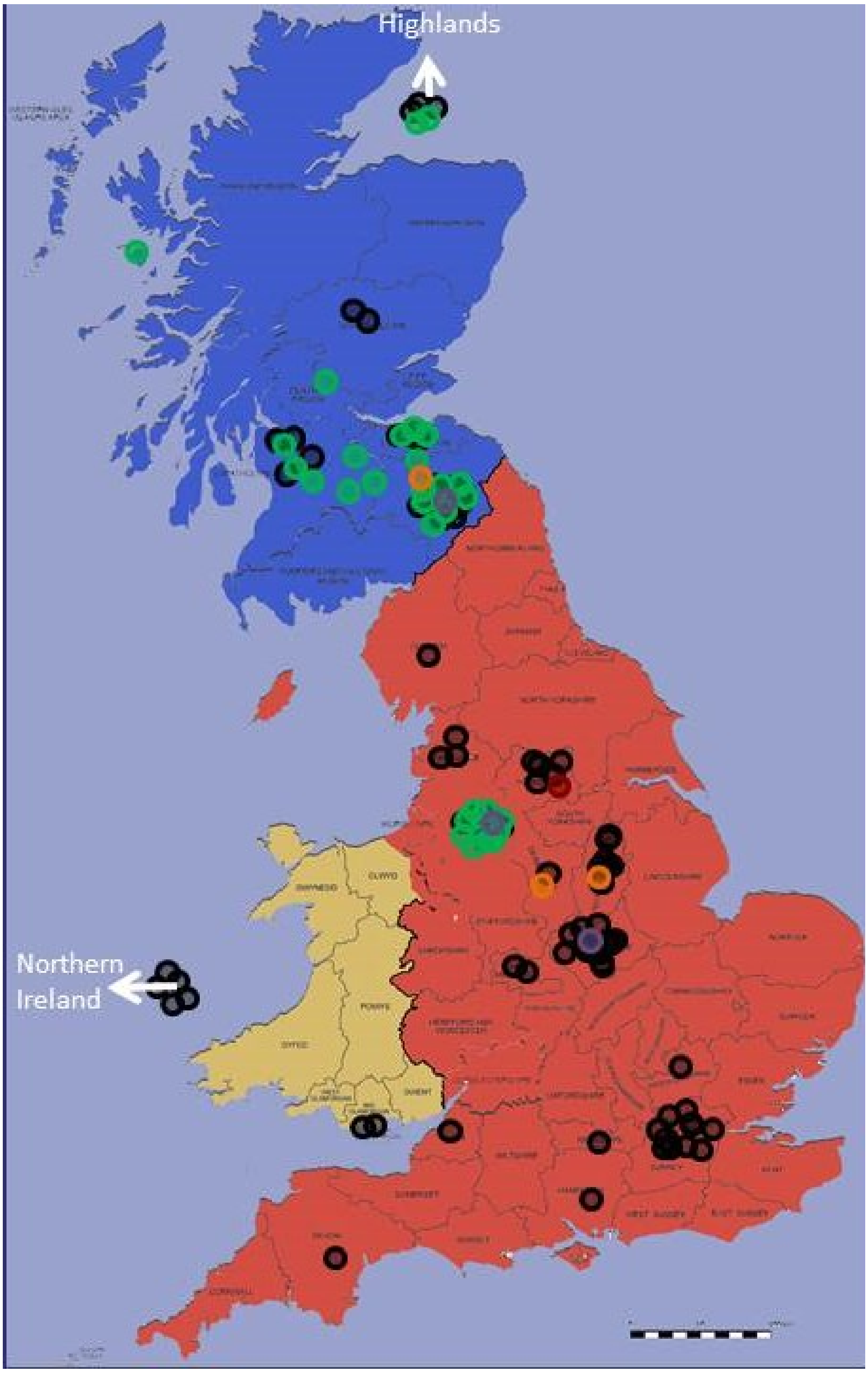


Figure 5.1 Map showing geographical locations of UK knitwear companies.

5.8 Summary

Eighteen knitting machine building companies were found through a review of secondary sources. The literature also clearly indicated that only two companies had developed commercially applicable complete garment technology, Shima Seiki in Japan and Stoll in Germany. Scrutiny of two key databases resulted in the identification of 116 companies in the UK producing knitted garments establishing a basis for a sampling frame. Data collected through literature identified five companies utilising complete garment technology. It was unclear at this stage however whether one of these five utilised only mini complete garment machinery for accessory production. Contact with trade associations produced confirmation that three of these companies are utilising the technology. Although the machine builders were reluctant to divulge information quantifying sales of machinery in the UK an informal telephone conversation revealed the identity of four manufacturers in the UK who have purchased the machinery, all of whom had been previously found through literature. Further online searches found two companies that have recently purchased the machinery and confirmed that the company using the mini machines also had complete garment capability. No further evidence was found to suggest that there are any more than seven companies manufacturing complete garments in the UK. Table 5.6 (p108) shows the contact details of the UK manufacturers found to be utilising complete garment technology and the sources through which they were identified.

Chapter 6 Data analysis: Machine builder interviews

6.1 Introduction

To analyse the utilisation of complete garment technology related to garment fit and the impact on product development, interviews with individuals who had direct knowledge of the technology were conducted. A review of literature had found that a considerable number of claims relating to the influence complete garment technology has on the garment had been made (Sections 3.6.2 p56, 3.6.3 p57 & 3.8.2 p62). It was considered important to explore these issues in more depth and the interviews with representatives from the machine builders provided a forum through which to solicit opinions from professionals working at the front line of technology implementation. Three face to face interviews were conducted in total. Two with two personnel from the UK offices of each machine building company. A third interview was conducted with an expert from head office of one of the companies. The fourth and final interview data was sent from Japan, via email at a later date.

For reasons of confidentiality the companies will be referred to as Machine builder 1 (MB1) and machine builder 2 (MB2). The first interview at MB1 was conducted initially with just the managing director of the UK office who will be referred to as interviewee MB1.a. When the questions became more technical however a technician was called in to provide expertise in this field. This interviewee will be referred to as MB1.b. The interview conducted at MB2 was conducted with a sales director (MB2.d) and a training technician (MB2.e). Additional interviews were conducted with the Fashion and technology co-ordinator from MB1 (MB1.c). This interview was restricted to 30 minutes and consequently provided less data. The chief of export division from MB2 completed a self-administered set of questions and the answers were therefore less in depth (MB2.f). The questions were ordered into a set of ten categories. Table 6.1 lists these themes with the corresponding number of questions.

Table 6.1 List of themes and question numeration

Theme	Number of questions
Personal introductions/company position	3
Utilisation of the technology within the global knitwear industry	3
Utilisation of the technology within the UK industry	5
Size and Fit regarding complete garments	7
Shaping and innovation regarding complete garments	11
Reduction in labour cost through utilisation of the technology	2
The impact on skills and training through utilisation of the technology	3
The ability to produce a mass customisation service through utilisation	2

6.2 Global utilisation of complete garment technology

To provide an International context through which to gauge the utilisation of complete garment technology in the UK, questions soliciting information regarding the global utilisation were initially posed. Responses from interviewee MB1.a indicated that the utilisation of complete garment technology was not thought to be significant. Geographically the largest investment had been in Europe with Italian and Spanish manufacturers purchasing the highest amount of machinery. There had been less investment in the USA. Two companies in Hong Kong were known have invested and a small number in Japan and Turkey. It was expected that the technology will be taken up in China in the future. The interviewees from MB1 explained that their machines with complete garment capability can also produce conventional knitwear. It was therefore not possible for them to know exactly how many knitwear producers were manufacturing complete garments. The Interviewee MB1.c estimated that 5% of the global market utilise machinery made by MB1 with complete garment capability. It was considered likely that this figure will increase. It was expected that labour rates would increase in the Far East but at the time of the interview, Chinese manufacturers were buying automatic machinery without complete garment capability. It was however predicted that Chinese manufacturers would eventually appreciate the advantages of eradicating post-production processes and invest in complete garment technology. The Gap, Banana republic, Sisley, Armani and Missoni are all brands that were identified by MB1.c as having included complete garments in their ranges. MC1.c stressed that it was not always possible to estimate the amount of knitwear manufactures who are producing complete garment because MB1 machines could be used to produce fabric lengths, fully fashioned panels or complete garments. It was this flexibility that was considered to be a ket advantage of MB1 machinery.

MB2.d estimated that a lower percentage of manufacturers had invested in complete garment technology (approximately 2%) and that Chinese manufacturers were not exploring the idea of utilising the technology. Twelve thousand machines were being produced annually by MB2; approximately one thousand have complete garment capability. Because complete garment technology has the flexibility to produce small batches of clothing it was thought to be more advantageous to European manufacturers producing a designer product. Interviewee MB2.e also stated that global investment in complete garment technology is currently small. The technology provides manufacturers with the capability to produce small batches and respond quickly. It is therefore appropriate for utilisation in high end production, such as the manufacture of cashmere garments.

6.3 UK manufacturers utilising the technology

Responses about the extent of utilisation of complete garment technology in the UK varied. MB1.a suggested that approximately six manufacturers were using it. One plant was identified as having eighty machines, the rest were small companies. Although MB1.a was asked specifically about the utilisation of MB1 machinery, the only plant with that many machines in Europe is known to utilise MB2 machinery. It appears therefore that the six companies identified by MB1.a will include those utilising machinery from both MB1 and MB2. MB1.a thought that UK manufacturers producing a higher end product had been more successful when utilising the technology than those producing a low end product. He suggested that the technology had improved and knit times had been reduced since its initial introduction but UK manufacturers were not yet able to exploit the full capabilities of the technology. He blamed the cost of the machinery for inhibiting investment and suggested that labour shortages in the UK would be the primary factor to motivate manufacturers to invest in complete garment technology.

MB1.c and MB2.e indicated that there were only a handful of manufacturers in the UK utilising the technology, MB1.c mentioned Spectrum Yarns who had adapted the yarn especially for use on complete garments. MB2.d estimated that approximately 12 companies were utilising complete garment technology in the UK. Two had large operations (KM1 has eighty machines), the rest are small concerns. The primary reason for investment in the UK was thought to be the opportunity to reduce labour requirements.

The UK representatives from MB2 claimed that they received many enquiries about the technology from UK manufacturers however the cost of the machinery and the lengthy knit times inhibited investment, particularly those producing a cheaper product. During the interview they made many speculative comments about the potential advantages of complete garment technology for UK manufacturers. For instance they drew attention to Asda's strategy to manufacture a percentage of their knitwear in the UK. Although this was perceived to be a marketing strategy they hoped that UK companies striving to reduce their carbon footprint would look favourably on complete garment technology in the future. The ability to respond quickly to demand was considered of primary importance to UK manufacturers because Chinese products have a long lead time. Utilisation of Complete garment technology was identified as enabling quick response. These comments did not however relate to any specific customer. They did claim that UK manufacturers were exploiting machine capability, however the ability to do so was acknowledged to depend on the skills of the designers and the technicians. Comments from this interview supported MB1.a's suggestion that labour shortages in the UK motivated knitwear manufacturers to implement complete garment technology.

6.4 Size and fit

Further questions explored the interviewee's attitudes towards the potential that utilisation of complete technology has to impact on the size and fit of knitwear.

6.4.1 Sizing consistency

MB1.a stated that complete garment technology eradicated the making up process and the subsequent size variation caused through human error. This increased the manufacturers' ability to maintain consistent garment sizing throughout production runs. MB2.d agreed with this analysis stating that complete garment machines can accurately reproduce every garment to the same size because the human element which can cause discrepancies in production during the cut and sew process is eliminated. An additional factor identified by MB2.d was an element of the machine programme (digital stitch) which controls the stitch length and enhances the accuracy of the garment dimensions.

6.4.2 Improved comfort and fit

Mb1.a claimed that complete garments were more comfortable through the eradication of abrasive seams and that MB1 customers had found it easier to create a garment that fits well when utilising complete garment technology (This claim was not explained or justified). MB1.c explained that superior fit is related to comfort, stating that MB1 have conducted research on base layer garments in collaboration with the sportswear company Odlem. The eradication of seams improves comfort particularly on sportswear and base layer garments as they are worn next to the skin. Outerwear garments such as pullovers are also said to be more comfortable. All the representatives of MB2 agreed that complete garments are more comfortable because the seamless structure is unrestrictive to body movement. MB2.e and MB2.f also suggested that seam eradication was particularly beneficial for sportswear and creating garments with close fit. To achieve fit, MB1.c stated that fit models were used at MB1. The UK representatives of MB2 explained that the MB2 technology included a mapping facility to simulate fit and draping on a virtual mode.

6.4.3 Utilisation of anthropometric measurement

When asked to provide the key body dimensions used to construct a complete garment only two of the interviewees responded (MB1.b and MB2.d). Table 6.2 lists the responses. It is clear that these dimensions relate to the garment and not to the body and therefore indicate that anthropometric measurement is perhaps not used within the development processes of complete garments at MB1 or MB2

Table 6.2 Key dimensions identified for garment development

Interviewee	Key dimension identified
MB1.b	Across Chest Sleeve width Cuff width
MB2.d	Chest Width Underarm Over arm Garment length

6.4.4 The impact of the technology on the sizing process

The sizing process was then explained. To achieve the correct garment size according to the customer’s specification firstly a finished piece of fabric is knitted for customer approval. The machine programme has a facility that calculates how many courses and wales there are per centimetre. This amount can be entered into the programme. If pre-programmed garment shapes are then selected, adjustments are automatically made to achieve a garment that meets the size specification. This process it was acknowledged does not necessarily create a perfect fit; invariably further adjustments have to be made. MB1.b was critical of the automatic programming which was not thought to perform as well as a programme developed by a skilled technician. The size charts used to specify garment dimensions are invariably provided by the retail customer and once the base or sample size is established grading is applied. Garments produced on complete garment machinery made by MB1 are knitted using half gauge which can create fabric that has an open appearance. It was therefore claimed to be crucial that the finishing processes are applied properly as this will improve the appearance of the fabric. Regarding the use of body measurements, MB1.c suggested that it is not advisable to use a fully fashioned specification for complete garment production. To achieve a correctly sized garment on complete garment machinery, MB1.c thought it necessary to have a cooperative relationship between the retailer and manufacturer because the process of knitting a three dimensional garment is so different to those used for fully fashioned manufacture. The comment indicates that the development process for complete garments is as yet somewhat fluid and that complete garment manufacturers must reinterpret the retailer's garment specification data in order to create appropriate programmes for complete garment technology. MB1.c and MB1.b described the grading process for MB1 technology, the key measurements (waist, hips etc) are keyed in to a programme called 'shaper' which is integrated into the CAD software. It is usually necessary however to make adjustments at least once maybe two or three times. None of the UK representative at MB1 had experience of the grading functions.

MB2.d claimed that the garment design and size specification can be input into the complete garment technology and knitted directly with no middle operation. However it was admitted that there was no guarantee that the first sample would be correct. Usually, it was acknowledged, there would be some adjustments to make. Another factor that influenced the size of the garment was identified by MB2.d as the knitting yarn. A cotton garment for instance was said to stretch after it had been knitted. The MB2 technology incorporates a database of sizes which are Japanese and do not relate to UK sizing systems. There is however a facility to add a new set of sizes. The garment can be designed and automatically sized on complete garment technology. No comment was made about the efficiency of this facility.

6.5 Shaping and Innovation

The ability to produce shaping innovation through the utilisation of complete garment technology was explored. Three key themes have been identified from the data relating to shaping and innovation: the function of the machine builder's sample garments, examples of innovation and factors inhibiting innovation.

6.5.1 The function of the machine builder's sample garments

Both MB1 and MB2 produce a sample collection of garments. At MB1 the advantage of flexible production was emphasised as a key advantage and the sample garments made at MB1 were claimed to demonstrate this for marketing purposes. MB1.a and MB1.b also agreed that the sample garments produced at MB1 demonstrated that complete garment technology was capable of driving innovation. The MB1 sample garments demonstrate this. Knitwear manufacturers using MB1 machinery can download sample garment programmes from the MB1 website. MB1.a.and MB1.b agreed that this facility is rarely used by knitwear manufacturers to recreate a garment. It is however more common for manufacturers to incorporate some of the technical design features from the sample garments into their own knitwear ranges. MB1.a identified the dresses created by the design and technology department to be aesthetically successful but because they take a considerable amount of time to produce they tend to be expensive. At MB2 every technician working in their design centre produces at least one totally new sample garment a week. This was done to demonstrate the unique machine capability of complete garment technology to knitwear manufacturers. Designers working for UK manufacturers can scrutinise the sample garments at the MB2 UK office. It is rare for the sample garments to be directly copied however they demonstrate new complete garment techniques which the manufacturers find useful.

6.5.2 Examples of innovation

The actual seamless structure of a complete garment when exploited to its full potential was identified by MB1.a to create aesthetic innovation. MB2.d and MB2.e agreed that primarily when MB2 machinery was purchased manufacturers copied fully fashioned styles. They then began to develop new styles to exploit complete garment construction methods. Examples of this development were identified by MB1.c, MB2.d and MB2.e as knitted yokes and unbroken pointelle, net and striped patterns. MB2.d also explained that gathers can be created for styles such as puffed sleeves. MB2.f claimed that complete garment technology provided opportunities to develop methods of joining the sleeves to the body on knitwear.

Differing market sectors were considered to have more opportunities to create innovative development. The technical sector was perceived by MB1.c to be the sector of the market most likely to create innovation. The interviewees from MB1 also provided an example of a medical application using MB1 technology (explained further in section 6.7 p119) MB2.d, MB2.e and MB2.f however considered that the fashion, sportswear and technical sectors of the market were all likely to produce innovative garments through the utilisation of complete garment technology. An example of innovative sports development was identified as a tennis shirt developed for professional players on MB2 complete garment machinery. The garment was knitted so the courses ran vertically down the garment instead of the conventional running horizontally across the garment. This approach, it was claimed, enabled the technician to create a garment which was a manipulation of one tube instead of three. Fashioning lines were said to be incorporated into complete garments purely for aesthetic reasons to maintain a fully fashioned appearance. MB2.e mentioned a facility on MB2 machinery that provides various automatic options for shaping such as methods of knitting the underarm. However, no evaluation of this facility was included in the discussion.

6.5.3 Factors inhibiting innovation

The cost of product development was considered by MB1.a to inhibit innovative garment design in the UK, in addition to the lack of skills or reluctance to experiment within a technical team. MB1.c also acknowledged that complete garment development demanded a high level of technical skills. To illustrate this point it was explained how Italian manufacturers tended to utilise freelance technicians working for pattern studios providing services specifically for complete garment design. MB2.d, MB2.e and MB2.f all also acknowledged that a lack of skills and investment in the UK knitwear industry hindered innovative complete garment development. MB1.b and MB1.c considered that there were more shaping limitations when making complete garment machines than when producing fully fashioned garments on straight bar knitting frames. It was recognised however that new shaping techniques were constantly developing at MB1. Responses from MB1.c revealed that when the technology was first introduced there were many limitations on garment shaping. Manufacturers who purchased the machinery at this time were therefore dissatisfied with the results.

6.6 Skills and training

MB1.a and MB1.b agreed that there is a considerable labour and skills shortage in the UK knitwear industry. All MB1 interviewees also acknowledged that utilisation of complete garment technology demands a high level of programming skills involving the ability to conceptualise the garment three dimensionally. MB1.b's experience led him to conclude that even the technicians working for MB1 in the UK had been unable to update their skills in order to maintain a sufficient level of knowledge to operate the most advanced technology.

MB1 run five to six week intensive courses at their headquarters. UK companies however are reluctant to invest in training. MB1.a admitted that complete garment technology helps to alleviate production skills shortages. MB2.d stated that when a large UK manufacturer invested in complete garment machinery technicians from MB2 were put on site for two years providing full time support. Manufacturers who had invested in complete garment technology from MB2 tended to send their staff for a three week training course, either in the UK or at company headquarters. The training support from MB2 is then on going. In the UK there is a considerable shortage of skilled production personnel. It was considered that there are still enough skilled personnel in the UK to exploit machine capability, however the numbers are declining. MB2.e suggested that technicians who are already trained to use MB2 automatic knitting machinery would have less difficulty when training to make complete garments. There is however a steep learning curve when training to programme complete garment technology.

6.7 Mass Customisation.

In regards to mass customisation, MB1.a stated that currently there is not enough information available to determine whether the utilisation of complete garment technology can provide opportunities. Both MB1a, MB1.b and MB1.c mentioned however a technical textiles development programme called 'scan to knit' which customises pressure garments to an individual specification using scan technology with knitting technology. This technology is currently in existence but the data is commercially sensitive as large sums of money have been invested and the research is on-going. MB2.d also recognised opportunities for developing customised products within the medical sector. In the fashion sector, MB1.b was sceptical whether there would be a demand for customised knitwear. In contrast MB2.d and MB2.e considered complete garment technology did provide good opportunities to create personalised garments through the utilisation of a good data base or library of designs. At the time of the interview however no one in the UK was known to be using the technology for mass customisation. MB2.d stated that the scanning company TC² have been collaborating with the KM2 USA office it was unknown however whether developments had occurred as a result.

6.8 Chapter summary

Complete garment technology is being utilised in the knitwear industry. Currently the majority of manufacturers are in Europe. There are between six and twelve manufacturers utilising the technology in the UK. This data supports the findings from phase one of the research (Chapter 5 p102), which identified seven knitwear manufacturers producing complete garments in the UK (Table 4.7 & 4.8). The issue of labour reduction through utilisation of the technology was found to be a highly sensitive issue during the interviews with the machine builders and there was a general avoidance of the question. Responses to other questions however show that the machine builders were aware that labour reduction is a primary motivator for manufacturers investing in the technology

The investigation into the suggestion that the utilisation of complete garment technology improves garment fit (Section 6.4 p114) revealed that both machine builders are basing their claims on anecdotal evidence. Consumers of complete garments are said to have described the fit as less restrictive to movement and less abrasive particularly when worn next to the skin. Both of these factors relate to comfort and have a direct relationship with the seamless structure of the garment. Seams restrict the extensibility of a knitted garment therefore complete garments will stretch on the body more than knitted garments with seams. The elimination of human error during the production process enables the maintenance of sizing consistency on complete garments. This factor has the potential to impact positively on garment fit. Any improvement is however dependent on firstly achieving satisfactory fit when producing the original sample garment and secondly the grading process used. These procedures currently rely on the application of trial and error. Both machine builders have participated in the development of custom fit garments. MB1 within the medical sector and MB2 have collaborated with TC^2 in the USA. The results of these projects however are currently unavailable

The interviews revealed that the utilisation of complete garment technology has a considerable impact on the process of product development. A range of shaping limitations and capabilities are likely to present a new set of parameters to knitwear designers and technicians. Complete garment manufacturers in the UK who originally copied the fully fashioned styles are now said to be producing new garment styles that exploit machine capability. Interviewees from MB2 were far more positive than those at MB1 about the manufacturer's ability to produce an innovative product. This may reflect empirical observations that have been made within the industry or the MB2 approach to marketing the technology. Both machine building companies produce sample garments to demonstrate the benefits of utilising the technology and educate manufacturing personnel. The machine builders are also investing in development of knitted products within the medical, sports and fashion sectors. There is potential to develop new innovative products and create niche markets.

Analysis of the interview data revealed little in terms of the utilisation of anthropometric data within the process of knitwear construction. Although the interview subjects are not presently working in the manufacturing industry two of the technicians had industry experience and therefore would have knowledge of how measurement is used to size a knitted garment. When asked to list the key body measurements used in knitwear production, the answers included garment and body dimensions. The creation of a complete garment sample and the graded sizes relies of trial and error. It was clear therefore that the interviewees were unaware of the importance of applying accurate anthropometric data during garment production. The machine builders' claims regarding garment sizing improvement through utilisation of the technology relates directly to the elimination of the post production process, which can create sizing inconsistency within a batch of garments of the same size. It does not in any way relate to a better use of anthropometric measurement during the sizing of complete garments. The interviews revealed no evidence to suggest that the ability of the machinery to create shaping that conforms to the body (paragraph 2.3.2) is based on a true understanding of how to produce garments that conform to body measurement.

Chapter 7 Case study analysis

7.1 Introduction

Three companies were purposively selected for case studies: knitwear manufacturer 1 (KM1), knitwear manufacturer 2 (KM2) and knitwear manufacturer 3 (KM3). This Chapter critically analyses the data from each case study independently and then conducts a comparative analysis between the findings from each company. Several sources of information were utilised to obtain background details relating to each case study knitwear manufacturer. Each individual company website provided information concerning the machinery, the company history and some background information about the product. Trade journals were reviewed and finally information relating to KM1 collected during the interviews was also included.

The data from the interviews and the observations were coded to form an initial set of categories. These initial coding categories varied slightly between each case study when the data dictated.

Table 7.1 Case study interview analysis: initial coding categories

Coding category KM1	Coding category KM2	Coding category KM3
Potential to innovate the knitted garment	Potential to innovate the knitted garment	Potential to innovate the knitted garment
Restrictions to innovation	Restrictions to innovation	Restrictions to innovation
Role disparities within product development	Role disparities within product development	Role disparities within product development
Shaping limitations	Shaping limitations	
Anthropometric deficiencies	Anthropometric deficiencies	Anthropometric deficiencies
Size and fit inconsistencies	Iterative fit procedures	Fit practice approximations
Iterative fit procedures	Innovative fit	

From these categories a general theme was identified as; The potential to Innovate the knitted garment. The analysis therefore sets out to evaluate the factors that enable or prevent UK manufacturers from exploiting the implied potential capability of complete garment to produce innovation. The term innovation is used in a general sense and refers to garment fit, shaping, sizing styling and design. Finally a comparative analysis of the findings from all three case studies was conducted and key themes relating to the utilisation of complete garment technology were identified. [Table]

7.2 Case study one (KM1):

7.2.1 Company history

KM1 is a subsidiary of a much larger UK clothing company comprising of five separate businesses, hosiery, lingerie, shirts and blouses, dyers and knitwear (KM1). The parent company was formed after a management buyout of Coates Viyella in 2000 and KM1, was purchased in 2004. They claim a knitting heritage dating back to 1865. The products were described as creative and innovative and manufactured for the mass market. Although KM1 produced in the UK, most of the other subsidiary companies operated from overseas factories. The KM1 website emphasised its ability to provide a highly responsive service to the UK market. This study Interview supports this claim and identifies a close relationship with the UK retailer Oasis with approximately one and a half million pounds worth of business being conducted per annum. Oasis spent the majority of their budget, approximately 85%, through the Far East. The remaining 15% of the budget was for trading in season from suppliers such as KM1 who can respond quickly. Retailers reduced their financial commitment by placing small orders with KM1 throughout the season.

KM1's plant was made up solely of eighty Shima Seiki SWG-X 12G. They produced 600,000 garments per year and claimed to be able to turn orders around faster than anywhere else in the UK or overseas. They listed their ability to supply to the fashion, sport or medical market sectors. In an article in Knitting International, KM1's chairman stated that using complete garment machinery enabled an improvement in garment design which increased profit margins (Mowbray 2007). There has been documentation of KM1's collaboration in a sportswear product development project with companies including Nike, Unifi Textured Yarns and Shima Seiki Europe. The aims of which were to produce innovative garments to be worn by top tennis players at Wimbledon (Mowbray 2006a). In 2002, KM1 were reported to be the most profitable knitwear manufacturer in the UK (Mowbray 2002c) and in 2007,it was claimed they were one of only two major plants using complete garment technology in the world and had survived against fierce Asian competition. Marks and Spencer and Sainsbury's were mentioned as KM1 customers (Siddons 2007). Since this case study was conducted, KM1 ceased manufacturing knitwear in the UK.

7.2.2 Garment innovation

The case study data provided a number of examples to show that KM1 had exploited shaping capability to create novelty. Unbroken pointelle patterns that circled the whole circumference of the garment had been particularly successful. Formally a producer of classic or in the words of KM1des1 'boring' fully fashioned knitwear, KM1's range of garment styles had greatly increased since the implementation of the technology. The introduction of dresses and skirts had been greatly appreciated by KM1's retail customers. KM1 have produced a variety of garments that exploit the ability of the machines to knit pointelle lace patterns. A number of methods to join the sleeves to the body were evident and in addition to traditional methods, yokes had been used. Yokes are knitted as a tube and particularly suited to complete garment manufacture. The garment observations revealed that the many of the garments were integrally knitted with a number of differing knit structures and the differing properties of the knitted structures had been exploited to create garment shape. Neck bands were all integrally knitted from a variety of knit structures. Narrowing and widening had been used to create shape on all the KM1 complete garments, particularly for armhole shaping. The garments observed were not shaped three dimensionally. Each new successful development generated template programmes to be used for new garment styles and reduce programming times.

Developments in sports, technical and medical garments had been successfully achieved at KM1. An experimental collaboration with Nike had produced tennis shirts worn at Wimbledon. These garments were generally acknowledged to include a high degree of innovation but were not considered to be commercially viable by Nike who did not pursue the project. Protective garments knitted using Kevlar were still being produced at the time of the case study. A collaborative development with a company who were developing garments for babies with eczema had not led to further business. This experimental work had all been initiated externally and although the interview data shows that it was generally acknowledged that sectors outside of fashion had huge potential, KM1 were not investing in research and development. It was therefore claimed that they did not have the manpower to diversify from their core fashion business.

7.2.3 Restrictions to innovation

Although it was evident that KM1 had been able to produce some innovative garments it was also clear that there were a number of factors that restricted innovation at KM1. Programming new styles was acknowledged to be excessively time consuming, plus the time to knit new samples was limited so as not to interfere with bulk production. These factors all restricted the development of novel design concepts. The interviewees also demonstrated a high level of scepticism about the ability of complete garment technology to influence a novel design approach and create innovation. They were very aware that a consequence of their position as a supplier to high street retailers was that they had limited influence on the garments they developed. The majority of these decisions were made by, according to the interviewees, young and inexperienced retail buyers who were criticised for being both unaware and disinterested in technically innovative products. The product was therefore developed primarily to conform to a pre-determined fashion profile selected by uninformed fashion buyers. Frequently KM1 were merely reproducing a style that had already been developed and produced in the Far East. As a result, the machine builder's samples were perceived to have limited value at KM1 because the samples were not perceived to be fashionable. The programs for the sample garments also required a high degree of modification before they were useable. Data analysis also revealed that manufacturers who rely solely on complete garment technology with no post production capability can feel that their product range is restricted. KM1 had to substantially reduce their margins by using a contractor to finish skirt waistbands on a style that had been commercially very successful.

The utilisation of complete garment technology had rendered traditional methods of pressing (the use of frames or boards to maintain the shape of the knitted garment) inappropriate. At KM1 two factors were identified as causing this change: firstly it was too expensive to be constantly ordering new frames for each new garment style. Secondly many of the novel garments being made at KM1, such as dresses, were judged to be unsuitable for this method. The garments were therefore pressed with equipment which is usually used for garments that are structurally more stable (steam irons and vacuum tables) and was considered to be unsatisfactory.

7.2.4 Role disparities within product development

Analysis of the interview data revealed that the technicians' role was evidently perceived to be pivotal within the development of the complete garment and subsequently highly valued at KM1. Personnel with both traditional fully fashioned knitting experience and the ability to programme the technology were not available within the UK. To utilise the technology at KM1 a considerable commitment to training the technical team had been undertaken. All the technicians employed at KM1 had two weeks training at Shima Seiki in Japan which was described as limited, partly because the methods of operation at KM1 differed from those taught. The technical manager at KM1 was a former Shima Seiki employee but he acknowledged that the majority of his expertise had been acquired empirically through practical application. It was claimed to take at least two years for the technicians at KM1 to gain full competency, a period where skills developed experientially, whilst working on production. The interview analysis revealed that the ability to exploit any potential machine capability was clearly dependant on the programming technician's abilities. Developing knitting programmes was acknowledged to be a challenge because, unlike developing flat panels for fully fashioned garments, the complete garment must be considered three dimensionally, whilst maintaining equal stitches on flat needle beds. If the shaping is executed incorrectly the knit structure is likely to be damaged. A detailed example relating to the configuration of stitches on the needle beds demonstrated how the tube was conceptualised as the back (on one needle bed) and the front (on the opposing needle bed) of the garment as if they were two separate panels. To solve a problem, the technicians had used some of the needles on the front needle bed to knit the back of the garment. This change of thinking was perceived as a problem solving exercise and demonstrates that the technicians have a tendency to adhere to fully fashioned methods. The technician also claimed that technical skills influence the degree to which fit satisfaction was achieved.

In contrast with the technical team the designers had received no formal training. Scrutiny of the Shima Seiki sample garments had been the primary method used to develop the design team's awareness of the capabilities and the limitations of complete garment technology. It was also evident that the designers initiate the garment designs, yet at KM1 they had not been provided with specific training. This clearly restricted their influence on the product range.

Interview analysis revealed that the design team were completely focussed on creating a garment that conformed to the demands of UK fashion retailers and trend research was considered a primary purpose of the design role. There were indications that the complexity of the designer's workload was reduced and that demanding tasks that would have been performed previously, such as detailed knit structure specifications, were no longer expected from them. The interviews revealed that they frequently had to persuade the technicians to attempt to overcome technical restrictions in order to achieve the results that they knew the market demanded. The designers expressed frustration at their lack of knowledge which restricted their ability to exploit the machine capability. The design role did not include the creation of garment shaping, designing complete garments at KM1 does not include the conceptualisation of a three dimensional structure that relates to a female body within the limitations of shaping capability.

7.2.5 Shaping limitations

At KM1 the interviewees worked within what they perceived to be the limitations of the complete garment technology which was determined by the technicians. Both the designers and the technologist had on occasion been informed by the technicians, that the specified neck and armhole shapes could not be achieved because of shaping (narrowing and widening) limitations. Voluminous gathered sleeves and polonecks were also understood to be beyond the scope of shaping capability. The designers' lack of technical knowledge rendered them less able to propose informed alternative methods that might challenge the decisions made by the technicians regarding shaping limitations. The designers were clearly focussed on fashion demands and trend compliance; they were not motivated to exploit innovative shaping concepts and the methods used to create garment shape, were not considered to be an integral function of complete garment design. The data analysis also revealed that shaping limitations can relate as much to production costs and the lack of technical skills as they do to machine capability. Methods to produce cardigans (a style that does not have a tubular body) had been developed even though it had been categorically stated that cardigans could not be commercially knitted. This example clearly shows that a progression in technical skills and knowledge can effectively reduce the perceived machine limitations. Problem solving exercises such as these are indicative that development is dependent on individuals who may or may not be motivated to meet such challenges. This is particularly pertinent as programming new styles was described as excessively time consuming.

7.2.6 Anthropometric data deficiency

There was no evidence to suggest that KM1 utilised anthropometric data to develop complete garments, instead previously established garment dimensions were utilised. The extensibility of the knitted structure was perceived to enable a flexible approach when determining garment dimension. The available data was considered limited and was inappropriately based on historical information formally used to develop fully fashioned panels. The technician at KM1 robustly criticised the lack of anthropometric data available to him and identified a key body dimension that he felt was necessary in order to develop tubular garments (Figure 9.3 p242). Although requests had been made for interview participants who utilised anthropometric data within the product development process, it was evident that none of the participants handled anthropometric data, only garment dimension. The case study data did not therefore reveal any clues to suggest the existence of an established methodology for determining the relationship between garment dimension and anthropometric data. The sizing data used for grading was supplied by the retail customers and was the same as the data supplied for fully fashioned knitwear production. The automated grading facility on the technology was not utilised, instead each garment size was programmed individually.

7.2.7 Size and fit Inconsistencies

In terms of size specifications, KM1's retail customers all had their own specific demands. There was no consistency in the sizing data provided by each retailer and their fit demands varied, for instance, some retailers preferred a tighter fit and others preferred garments that had a looser fit. The interviewees attributed this inconsistency in demand to the fact that each retailer was attempting to satisfy the fit preferences of their particular target consumer. Those with an older target consumer stipulated garments with a looser fit and it was invariably not until the fit trials that these decisions were voiced. Only one of KM1's retail customers conducted trials for size 16 in addition to the sample size (12) and the size coding systems requested also varied between descriptive (S, M, L) and double numeric (10,12,14). In addition the tolerances demanded by the retailers were frequently inappropriately low (as little as 0.1cm) for knitwear which is unstable and impossible to measure with that degree of accuracy. The interview data revealed that it appeared to be generally accepted by KM1 personnel that they had to deal with buyers who were ignorant of the very specific character of their knitwear. This ignorance created a palpable lack of respect.

A number of examples occur within the case study data to demonstrate that many of the decisions taken during product development processes are based on approximations or informed guesswork. The technician's interview data includes admissions that the process used to calculate the stitch density when determining the dimensions of the garment was frequently omitted from sizing procedure. Instead decisions were based on historical knowledge from previous stitch density calculations. Information was at times reinterpreted as it passed between departments, for instance the technicians admitted that they tended to use garment dimensions that they thought were correct, rather than use the data specified by the designers. Graded garments were fit assessed using factory staff as models and to compensate for the fact that none of the models were compliant to the size data approximated adjustments were made. Finally the process of determining garment dimension was based on limited and inappropriate data and therefore relied on the ability of the technicians to make modifications based on their own experience or empirical knowledge acquired through trial and error

7.2.8 Iterative fit procedures

The processes used to establish fit were acknowledged to include a high degree of iteration. All the sample garments produced at KM1 were assessed at a fit trial in their factory and at their retail customer's premises. Invariably at least two fit trials were conducted before customer approval was met. The fit trials were initially conducted on one sample size, usually a 10 or 12 and then graded samples would also be assessed in the factory before going into production. Prototype samples of graded sizes were not always found to be satisfactory and may have to be modified before production commences. Having to repeatedly make modifications was a source of irritation for the technicians who, it was claimed, could be resistant to making labour intensive minor adjustments demanded by the retail customers.

Analysis of the interview data a general recognition of differences in the way complete garments fitted the body. The technicians suggested that the seamless structure created additional extensibility and a more comfortable fit. The designers noted improvements in relation to the tubular structure of flared dresses and skirts which resulted in an even hemline and consistent drape. This degree of fit satisfaction it was suggested had not been possible when dresses and skirts were made from knitted panels. The general perception was that their retail customers were unaware of the potential impact the technology could have on fit.

7.3 Garment observations (KM1): Analysis of findings

The analysis coded two aspects of the garments: the knitted structure(s) from which the garment is comprised and the method used to create garment shaping, paying particular attention to techniques specific to complete garment manufacturing.

7.3.1 KM1 Garment observation: Knit structures

The four KM1 garments were constructed using a variety of knit structures including 1x1 rib, plain knit and two different pointelle structures. One skirt was made entirely of pointelle (Table 7.4 p 134) and was integrally shaped so as the circumference of the knitted tube increased from the waist to the hem, the pointelle pattern also increased in size. The tubular structure of the fabric means the structural pattern is unbroken by any seams, a feature also evident on a pointelle yoke shown in Image 1.3.1, 1.3.2 & 1.3.3 (Table 7.5 p135) Both these garments exploit the seamless aspect of knitting tubular structures. All the garments from KM1 demonstrate how complete garment technology has the capability to change knit structures seamlessly within a garment.

7.3.2 KM1 Garment observation: Shaping and innovation

It must be acknowledged that there is a direct relationship between knit structure and garment shaping and it is therefore difficult to discuss one in isolation to the other. Garment KM1.1 (Table 7.2 p132) relies heavily on the differing properties of knitted structures to create shape. It has a bodice knitted in 1x1 rib, whilst the skirt section of the dress and the sleeves are a plain knit. In its collapsed state, the rib has a smaller circumference than the plain knitted skirt section and will mould around the body when worn. Differing knit structures are strategically placed on the garment, in this case the waist, to create shapes to fit the body. The plain knitted skirt section uses narrowing at either side of the knitted tube to create a flared shape from the waist (Fig 1.2 Table 7.2 p132). This method of shaping creates a 2D shape and does not place flare evenly around the circumference of the garment as seen in the pointelle skirt (Image 1.4.1 Table 7.4 p134). In addition neither the skirt nor the dress make allowances for differences between the front of the body where there is an abdominal curve or the back where the lower back indentation and the buttocks create considerable variance in girth dimension.

The three KM1 garments with sleeves, all utilise different methods of armhole and sleeve shaping. Garment KM1.1, the dress (Table 7.2 p132) has a set in sleeve. Some fashioning marks are visible at the underarm, where the armhole has been narrowed to form a slight curve. A number of wales of rib stitches run the full circumference of the armhole. This method of armhole shaping exploits the ability of a rib to expand and collapse at the underarm region of the body where there is considerable dimensional change through movement. Garment KM1.2 (Table 7.3 p133) the pointelle top, has a raglan sleeve with visible fashioning marks where narrowing has occurred at the armhole (Image 1.2.2 Table 7.3 p133). This garment also has a number of rib wales circling the armhole. Garment KM1.4 (Table 7.5 p135), the pointelle yoke top, has an integral yoke which forms the upper portion of the garment. The armhole shaping therefore only occurs from the under arm to the point where the sleeve and body tubes meet the yoke. Fashioning marks show where narrowing has occurred (Image 1.3.2 Table 7.5 p135).

Garments KM1.1, KM1.2 and KM1.4 all have neck bands knitted integrally. Garment KM1.1 is a scoop neck and appears to exploit the collapsible property of the rib structure to help to create the necessary neckline curve (Image 1.1.3 & 1.1.5 Table 7.2 p132). Garment KM1.2 is a V neck (not visible from the available images) with an integrally knitted neckband. The pointelle yoke top has a neckband that consists of eight horizontal purl courses integrally knitted.

None of the KM1 garments were shaped three dimensionally and would appear completely flat if laid on a surface. These garments do not attempt to replicate body curvature such as the bust, the buttocks, the waist and the hips.

Table 7.2 Garment observation KM1.1 rib dress

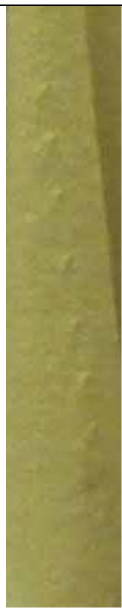
Company KM1 **Garment description** Long sleeved dress KM1.1 **Range** / **Size** Spring 2007 / 12 **Knit structure** Rib body, plain skirt and sleeves **Shaping**	 Image 1.1  Image 1.2
Seamless set in sleeve (image 1.1.3), scoop neck. This type of shaping (image 1.1.4) will exploit the maximum extensibility of the structure at a body region that has a large dimensional change through arm movement. The integrally shaped neckline shows how a rib structure behaves like a collapsing spring (Image 1.1.5) **Innovation** Integral neckband and seamless garment structure. The capability to shape three dimensionally has not been exploited	 Image 1.1.3  Image 1.1.4  Image 1.1.5
Source of image	Photograph taken by the researcher on KM1 premises

Table 7.3 Garment observation KM1.2 pointelle top

Company	
KM1	
Garment description & code	
Long sleeve cable sweater KM!.2	
Range	Size
Spring 2007	12
Knit structure	
Cable, plain and rib body and plain sleeve (image 1.1.1)	
Innovation	
Integral neckband incorporating a cable (Image 1.2.4).	
Shaping	
Seamless raglan sleeve ((image 1.1.2), Integral V neck with	

Image 1.2.1

Image 1.2.2

Image1.2.3

Image 1.2.4

Source of image	Photograph taken by the researcher on KM1 premises

Table 7.4 Garment observation KM1.3 Pointelle skirt

<table>
<tr><td colspan="2">Company</td><td rowspan="14">
Image 1.3.1</td></tr>
<tr><td colspan="2">KM1</td></tr>
<tr><td colspan="2">Garment description & code</td></tr>
<tr><td colspan="2">Pointelle skirt KM1.3</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>Spring 2007</td><td>12</td></tr>
<tr><td colspan="2">Knit structure</td></tr>
<tr><td colspan="2">Pointelle</td></tr>
<tr><td colspan="2">Innovation</td></tr>
<tr><td colspan="2">Unbroken seamless pointelle pattern around its whole circumference</td></tr>
<tr><td colspan="2">Shaping</td></tr>
<tr><td colspan="2">The fashioning is integrally incorporated into the pointelle structure image 1 shows that the pattern increases in size as the circumference of the skirt increases</td></tr>
<tr><td colspan="2">Source of image</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Source of image</td><td>Photograph taken by the researcher on KM1 premises</td></tr>
</table>

Table 7.5 garment observation KM1.4 pointelle yoke top

Company	 Image 1.3.1	
KM1		
Garment description & code		
Pointelle neck ladies top KM1.4		
Range / Size		
Spring 2007 / 12		
Knit structure		
Pointelle neckline Plain body and sleeves (Image 1.3.1)	 Image 1.3.2	 Image 1.3.3
Innovation		
Unbroken pointelle pattern circling the circumference of the neckline (image 1.3.1)		
Shaping		
The pointelle neckline is knitted as a complete yoke then joined to the body and sleeves at mid armhole point (image 1.3.2)		
Source of image	Photograph taken by the researcher on KM1 premises	

7.4 Case study 2 (KM2): Company history

The marketing literature from KM2 provides a brief history of the company (Table 6.1). This summary of important events in the company history shows they value their heritage, their status as a classic knitwear producer and the luxury fibres they use. They have also highlighted their use of innovative technology in relation to its ability to create novel products. They have a fully operational on-line sales service.

Table 7.6 KM2 Key data listed historically

Date	Significant event
1784	KM2 was founded
1922	Sea Island cotton was introduced. At this time the company was only producing underwear.
1930	Outerwear was introduced alongside the established underwear business
1932	Garments that are now considered classic KM2 designs were first introduced
1960s	Outerwear was now the main focus of the business. Company begins to export
1993	New Japanese machinery enables the production of patterned and textured garments
1995	New Zealand Merino wool is introduced as a new luxury fibre
2005	KM2 launched an on-line sales service
2006	The announcement of the introduction of complete garments in the range described by KM2 literature as ‘unique, lightweight and seamless’.

KM2 promote their product as coming from a long established tradition of knitwear manufacturing in the UK. It is claimed that generations of skills in knitting and hand finishing can be found within the community local to factory premises. KM2’s unique selling point is the production of fine (24-30) gauge (needles per inch) knitwear. The garments are described as updated traditional designs. It is clear from company literature that KM2 knitwear is marketed as a quality product that is expertly hand finished. In contrast to their classic image KM2 emphasise their innovative approach and forward thinking attitude in terms of the use of new technologies. They claim to be one of the first companies to install Cotton’s Patent knitting machines to produce fully fashioned underwear in 1877. In addition KM2 promote their knitwear as fashion garments, having collaborated with internationally renowned designers such as Vivienne Westward and Comme des Garcons. 70% of KM2’s products are exported. The KM2 website is an online sales facility and a promotional tool, although this facility did incorporate a fit guide in 2009, this facility is no longer available. An online brochure shows a complete garment range. The promotional text advocates the seamless garments and claims they provide superior fit. KM2 produce menswear, womenswear, children's wear and lingerie. In the UK KM2 is known primarily as a men's wear brand (Mowbray 2005b). In an article in knitting international KM2's managing director, describes their approach to complete garment technology as exploiting machine capabilities, such as integral shaping in order to create an innovative product (Mowbray 2005b). It was also hoped that complete garment technology would help to address skills shortages, however there's no mention of how KM2 had addressed staff training in order to fully exploit the machine capabilities.

7.4.1 Garment innovation

Typically known for their classic range of traditional fully fashioned styles, there were many examples from the interview and observation data to reveal that KM2 were producing novel complete garments. The Japanese designed garments, although they had caused production problems were good examples. A garment developed from a Shima Seiki program knitted with the wales running horizontally to overcome dimensional restrictions caused by the width of the needle beds was also acknowledged as innovative. Although the development processes had been problematic, a database of successful new templates for future garment development had resulted. Style features such as Funnel, cowl and roll necks were listed as novel garment features that had worked well on complete garment machinery. During the garment observations it had been possible to identify novel shaping techniques that had been developed for the Japanese garments (Table 7.14 p153 & Table 7.15 p154), incorporated more successfully into garments that were designed by the KM2 design team (Table 7.16 p155). Innovative shaping techniques such as zigzag armholes (Table 7.13 p152) were also incorporated into simpler garment shapes creating more subtle novelty. This approach was claimed to have been more commercially successful. The ability to shape within a tube was recognised to create flared skirts and dresses that were acknowledged to be far more satisfactory to those produced on fully fashioned machinery.

Analysis of the garment observation data revealed that 3D shape that conforms to body curvature had been created with the inclusion of shaping on the shoulder that performed a similar function to a dart (Table 7.7 p146 & Table 7.8 p147). Some of The garments do however indicate that the 3D shape could be improved through greater knowledge of a) the complex 3D structure of the body b) the ability to create 3D shape within a knitted garment through the exploitation of new shaping methods and c) an understanding of how to create 3D shapes for garments that fit and flatter the body. Although 3D shapes had been created, some of this shaping appears to have been lost or destroyed during the pressing process where methods do not accommodate 3D garments (Image 2.9.3 Table 7.17 p156).

There were more garments with set in sleeves than any other armhole shape. The garment observation analysis also suggests that there is room for improvement in the execution of some of the garment shaping. For instance some of the body tubes had been eased into the sleeve tubes when the garment sections had been joined, causing fabric pucker (Image 2.6.1 Table 7.13 p152 & Image 2.4.2 Table 7.11 p150). There was very little evidence from the garment observations to suggest shaping had been used to replicate the shape of the waist and the hips. One garment did however use a shaping technique which created some form of 3D shaping at the bust (Image 2.9.5 Table 7.16 p155). However as the back of the garment was shaped in exactly the same way it is difficult to assess whether this shaping was intended to specifically create bust shaping or whether it was a device to create a rounded draped body shape. Two of the garments had rib bands applied which created shape at the waist. Narrowing and widening had been frequently used and integral shaping methods had been used to create 3D shaping. The inclusion of a paddle system on the machinery which has the ability to hold stitches during the knitting process without causing damage to the structure of the fabric was identified by the technician as the machine function that enabled a greater variety of shaping. The interviewees at KM2 acknowledged that they produce a relatively high price garment. Data analysis revealed that this provided some flexibility regarding both sample development and production knit times. They were therefore more able to adopt an experimental approach and absorb the cost associated with laborious programming.

At KM2, the utilisation of complete garment technology was attributed to the decision to re-introduce children’s wear. This decision was a direct result of the ability to knit the garment in one process. Knitting children’s garments as fully fashioned panels had been found to be too labour intensive. KM2 were also planning to introduce more luxury fibres which was considered to be possible because complete garment technology minimised waste. In addition a service to customise garments to meet individual customer’s demands had been considered as a direct result of utilisation of the technology.

7.4.2 Fit innovation

KM2 had at times experienced difficulties in achieving the required fit results on their complete garment range. However despite these difficulties, KM2 promoted their complete garments as having superior fit and the interview data indicates that the utilisation of the technology had been found to have had an impact on garment fit. Experimental shaping for instance had resulted in a garment with what was described as ‘a different type of fit’. Complete garments had also been found to fit a broader spectrum of body shapes and sizes than fully fashioned seamed garments did and KM2 had therefore reduced their size range. This change was claimed to be due to the seamless structure of the garment which created additional extensibility. The interviewees at KM2 presumed that the end consumer would be unaware of potential fit benefits of complete garment

7.4.3 Restrictions to innovation

As the development of complete garments is initiated by with the design team, the lack of training the designers receive in relation to complete garments must restrict their ability to exploit machine capability. In terms of innovation, the interview data suggested that the design team were enthused by the notion of creating novelty and innovation, however they could not always make an informed argument to achieve the end results they desired. There were also time restrictions on sample programming and as only six machines were available for both bulk and sample production it was difficult to find a suitable time to knit samples. KM2 produce fine gauge knitwear and this had been found to cause some quality issues particularly in regard to integrally knitted neckbands. V necked garments for instance had been found to crack at the centre of the V when pulled over the head. This problem was resolved by linking on neck trims as a post-production procedure. The majority of the garments observed at KM2 were a plain knit structure with rib cuffs, waistbands and necks applied as a post-production operation. The garments observed provide evidence that KM3 were heavily reliant on being able to conduct post-production operations. This case study reveals that currently it is actually very difficult for knitwear manufacturers to operate a plant entirely with complete garment technology, particularly fine gauge knitwear. There is therefore still a dependence on skilled labour to finish garments that have to be knitted in more than one component part. KM2 who had a range of different machinery to choose from did not knit cardigans on complete garment technology.

At KM2, sophisticated pressing equipment that used laser technology to register the required garment dimensions could not be used for innovatively shaped garments and was particularly inadequate for 3D structures. This was a significant problem as the pressing process was acknowledged to be important for maintaining garment dimension. The garment observation data provides evidence that 3D shapes that had been created through novel shaping techniques had been damaged when the garment was pressed flat.

7.4.4 Role disparities within product development

At KM2 only 6 complete garment machines were utilised and one technician, a former Shima Seiki employee was responsible for all the programming for complete garment development and production. He agreed that his workload had increased. and that the development process had become more complex and over reliant on technical skills and knowledge. The technician had been trained by the machine builders in Japan. He claimed that language barriers between the machine builders and UK personnel had detracted from the effectiveness of the training. Most of his specific complete garment skills had however been learnt whilst programming garments for production at KM2.

The analysis indicates that technician’s role demanded an understanding of the relationship between the garment and the knitted stitch and the ability to conceptualise three dimensionally. It was acknowledged that the technician was still relatively inexperienced which KM2des claimed hindered their ability to improve fit. It was evident however, that the technician had control of the final decisions taken during the product development process. He criticised the information provided by the designers on the specification documents, as being inaccurate and in need of modification. Experimental garments designed in Japan had been viewed as a beneficial learning experience for all the KM2 personnel involved. The interviewees claimed that the Japanese designers had been more able to exploit the machine capabilities because they were supported by the Shima Seiki technicians in Japan and could converse directly in Japanese.

The designers at KM1 had received no formal training for complete garment technology and their skills and knowledge had been acquired empirically through practical application and scrutiny of the Shima Seiki samples. This had helped them to recognise capabilities and limitations of the technology. There was evidence that the design team were frustrated at not being informed enough to challenge the technician’s authority. This restricted their ability to influence important development decisions. The analysis also suggests that the designers need to develop more accurate and detailed methods of creating specification documents. KM2des admitted that it had taken approximately two years for them to determine the shaping limitations of the technology.

7.4.5 Shaping limitations

The KM2 garments that had been designed by the Japanese designers had utilised shaping with extreme angles. Although the prototype samples had passed through quality control, during bulk production, the extreme angles had caused constant damages in the garments. This experimental approach had been a costly method of determining shaping limitations. The technician had criticised the Japanese designers for not compromising, however analysis of the observational data indicates that a more sophisticated understanding of how to create three dimensional garment shape may have achieved better results. Some of the garments that were described as being balloon shaped had widening and narrowing using only the needles at the edge of the knitted tube as they were configured on each needle bed. This does not create a 3D balloon shape, but a 2D shape with curved sides (Image 2.8.3 Table 7.15 p154). This observational finding demonstrates that having to think three dimensionally is challenging for the technician and emphasises the impetus to think of the two needle beds as relating to the front and back of the garment, an approach mimics traditional fully fashioned methods which many knitwear technicians are very familiar with.

7.4.6 Anthropometric data deficiency

KM2 were aware that the anthropometric data they were working with was limited and the need to access both UK and International anthropometric data had been identified as a priority. Analysis of interview data and specification documents revealed that the dimensions of new products were based on pre-established garment dimension, not anthropometric data. The data used at KM2 had originated from fully fashioned garments and this had been found to be inappropriate when developing complete garments. The process of determining garment dimensions involved a calculation to translate measurement data into the relative number of courses and wales for each different knit structure. This process was carried out by the technician who programmed the complete garments.

A methodology to determine the extensibility of differing knit structures and their relationship to garment and body dimension was however evidently lacking. Sizing data are provided with the Shima software and garment dimension can be automatically generated. This facility was not used as results were found to be unsatisfactory, as was the automatic grading facility which was found to decrease the ability to control production problems. The technician complained that specification documents provided by the designers included inaccurate sizing data which had to be modified. Very specific terminology, such as ‘basque’ (used to indicate the chest region of the garment) was used to define the garment. These terms were only found in the case study data at KM2. In addition, the documents do not include all the measurement data needed to define the garment and although a chest measurement is specified no bust measurement is included. The grading increment is 6cm, confirming that KM2 have increased their grading increment for complete garments (1.1.1.1Appendix F309).

The development of sizing at KM2 is based on their own historical data. They do however supply an international market and recognise a need to be more informed in regards to appropriate data from a variety of International sources. Currently they use the same system for their UK and international consumers which was acknowledged to be unsatisfactory. They also recognise that their customers have fit preferences influenced by fashion which changes over time and influences the need to constantly update the fit of the templates used. KM2 garments were all based on a small number of classic body shapes, determined through a series of fit trials to create either a looser or tighter fitting garment At the time of the case study the garments were described as slim fit for a fashionably toned body. KM2 used descriptive size coding throughout their ranges (S, M, L).

7.4.7 Iterative fit procedures

At KM2 achieving fit satisfaction when developing complete garments had been found to be difficult and time consuming. Analysis of the interview data revealed that iterative cycles of development and modification were common and examples where fit satisfaction could not be achieved. The inability to fully exploit machine capability to improve fit appeared to be aggravated by an inexperienced technician who was still developing skills. The designers did not appear to be able to offer solutions to problems that occurred when trying to create the desired fit.

The fit trials at KM2 are conducted using factory workers as the fit models for prototype samples and graded samples and it was claimed that it was important to see the garments on a variety of body shapes. This demonstrates the notion that extensible knitted garments will fit a broad range of body shapes which influences the approach taken to creating fit. There was however no acknowledgement of how it is possible to achieve sizing consistency when such a variety of differing body shapes are used to determine fit, particularly relevant when the data strongly indicates that it is the fir trials that really determine the eventual relationship between the garment and the body. Two variables that impact on garment size were identified as: knitting tension and extensibility of the knitted fabric. However no methodology to determine the extensibility of differing knit structures and their relationship to garment and body dimension was evident within the product development cycle.

7.5 Garment observation KM2: Analysis of Findings

Photographic documentation of the garments at KM2 was carried out in the showroom and the factory. The garments identified in the interview data as both innovative and problematic were in production at the time and were therefore accessible. Unfortunately these photographs had to be taken in restricted space which affected the quality of the image. One garment from KM2 (Garment KM2.9 Table 7.16 p155) was also purchased from the factory shop which has enabled a more thorough analysis.

7.5.1 KM2 Garment observation: Knit structures

The analysis of the knit structure revealed that the majority of the KM2 garments were manufactured in a plain knit with rib neckband, cuffs and welts. One of the images clearly shows that the neckband is linked on as a post-production process (Table 7.13 p152). Garments KM2.7, KM2.8, (Table 7.14 p153 & Table 7.15 p154) are images of the balloon shaped garments from the Japanese designed range. A collapsing ribbed welt helps to create the balloon like shape. Only KM2.3 and KM2.9 (Table 7.10 p149 & Table 7.16 p155) had a patterned knit structure. KM2.3 (p149) was a top knitted in a pointelle pattern with a wide rib welt that creates shaping at the waist and a rib cuff. KM2.9 (p155) was knitted predominantly as a plain knit, however the sleeves were knitted in a pointelle structure and pointelle detail was integral to the garment shaping (detailed in the following section). Finally garment KM2.5 was knitted purely as a plain knit. This garment was designed to drape around, which may have influenced the decision to use a plain knit structure.

7.5.2 KM2 Garment observation: Shaping and Innovation

The images of the garments at KM2 provided information regarding a good variety of shaping methods. Numerous examples of innovation in regards to shaping have been identified. These include: a variety of novel armhole shapes (KM2.1 Table 7.7 p146, KM2.4 Table 7.11 p150, & KM2.6 Table 7.13 p152), garments that had been shaped to form a balloon or puffball shape when worn (KM2.7 Table 7.14 p153 & KM3.8 Table 7.15 p154), an asymmetrically curved shaped top (KM2.11 Table 7.21 p181) and top with a seamless striped neckline (KM2.10 Table 7.20 p180). Set in sleeves were the most common form of armhole shaping (KM2.2 p148, KM2.3 p149, KM2.7 p153, KM2.9 p155 and KM2.11 p181). KM2.1 (p146) had raglan style armhole shaping. The zigzag shaped (KM2.6 p152) armhole and sleeves is both aesthetically and technically innovative. The images of both KM2.4 (p150) and KM2.6 (p152) indicate that the dimension of the sleeve and armhole are not equal and fullness has been created where the sleeve and body are joined. Figure 2.4.1 and 2.4.2 (Table 7.11 p150) show the garment hangs in folds from the armhole and the sleeve above the join is smooth. It is therefore likely that the dimension of the armhole at the underarm region is greater than the sleeve. Figures 2.6.1, 2.6.2 & 2.6.3 (Table 7.13 p152) show a similar result, however this garment has some fullness around the sleeve head as well as fullness in the body under the armhole. Garments KM2.7 (p153) and KM2.8 (p154) were described by KM2des and KM2tec as balloon shaped. However the analysis suggests they were predominately shaped using a method influenced by shaped panelled garments, namely the widening and narrowing was placed where side seams would be resulting in a 2D garment with curved sides. The attempt to achieve a 3D balloon shape was therefore not totally successful. KM2.8 the balloon skirt does however include some integral shaping (Image 2.8.4 Table 7.15 p154). A rib welt is also utilised to decrease the width of these balloon garments around the perimeter of the hem and emphasise the puffed shape.

Garment KM2.11 (Table 7.21 p181) from the same range as the ‘balloon shaped’ garments was asymmetric. Its, right side is longer than the left, so when laid flat its sides are curved. Unfortunately the photographic data is not good enough to conduct any depth of analysis as to how this has been achieved. Speculatively wale widening from left to right has been utilised to create this innovative shape. The image shows the garment is lying flat on a surface which indicates the shaping is localised to what would have been the side seams. Garment KM2.12 (Table 7.22 p182) has balloon shaped sleeves which are pointed on the underside of the sleeve and curved on the topside of the sleeve. This shaping (narrowing and widening) has been performed in two lines from the underarm to the wrist and from the central shoulder point to the wrist. The resulting shape will therefore be 2D when placed with the front directly on top of the back (Image 2.11.2 Table 7.20 p180).

KM2.5 (Table 7.12 p151) shows a garment that was developed from a Shima Seiki sample. The manufacture of this garment employed an innovative technique knitting with the wales running horizontally across the body. This enables the creation of greater width than the needle beds would allow if knitted with the wales running vertically. Garment KM2.1 (Table 7.7 p146), has a cap sleeve and fairly complex armhole and sleeve shaping which warranted an in depth analysis. The garment has been narrowed to create two lines of fashioning points that radiate inwards from the shoulder curve to the side neck point (Image 2.1.2 p146). This shaping technique looks very much like flechage, used to increase and decrease course length. There is raglan style armhole shaping and a number of rows of wale loops which run parallel to the neckline between the rib neckband and the sleeve head (Image 2.1.4 Table 7.8 p147). It is difficult when evaluating the shaping to understand how the garment has been knitted on the machine and ascertain where the three tubes (body and two sleeves) meet. To help to conceptualise the shaping methods used, the photographic images have been marked to show the direction in which the wales run in each section of the garment (Table 7.7 p146). Fashioning lines (narrowing and widening) have been outlined with a turquoise line. The addition of yellow lines to the images, indicate the join between the sleeves and the body. It is possible to determine that the sleeve shaping will have produced a 3D shape to accommodate curvature at the shoulders. The image also reveals a crease line running from the side neck point to the end of the sleeve (Image 2.1.2 p146). The garment has been pressed flat, demonstrating that no appropriate method for pressing 3D garments was available at KM2.

KM2.9 (Table 7.16 p155) had a complex set of shaping, creating a garment shape that conformed to a conventionally fitting knitted top above the bust line. The sleeve is set and the shoulder line is dropped towards the back (Image 2.9.1). Below the bust line, integral shaping increases the width of the body tube. (Images 2.9.4 & 2.9.5 Table 7.18 p157). Narrowing has been incorporated into eight lines of pointelle structure. These shaping lines run diagonally away from the centre front and centre back, towards the sides of the garment (Figure 2.9.6 p157). This narrowing decreases the width from its widest point (at hip level) towards the rib welt (at upper thigh level). There is no evidence of widening or narrowing occurring directly at the side of the garment, however the garment has been pressed flat with creases at the side. Although integral shaping is clearly present to create 3D garment shape, pressing the garment flat has compressed the integral shaping. The crease-line prevents the garment from draping correctly (Image 2.9.3 Table 7.17 p156). The front of the garment is exactly the same shape and size as the back, apart from the neck and the shoulder line. No allowance has been made for very obvious differences between the front and back of the body, such as the bust, the curvature of the spine or the abdomen.

Table 7.7 Garment observation KM2.1 cap sleeve top

<table>
<tr><th colspan="2">Company</th><td rowspan="13"> Image 2.1.1
 Image 2.1.2
 Image 2.1.3</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><th colspan="2">Garment description & code</th></tr>
<tr><td colspan="2">Cap sleeve top (KM2.1)</td></tr>
<tr><th>Range</th><th>Size</th></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><th colspan="2">Knit structure</th></tr>
<tr><td colspan="2">Plain body and sleeves,rib neckband, cuff and welt</td></tr>
<tr><th colspan="2">Innovation</th></tr>
<tr><td colspan="2">Innovative sleeve shaping (2.1.2 & 2.1.3). Stripes highlight the sleeve shaping.</td></tr>
<tr><th colspan="2">Shaping</th></tr>
<tr><td colspan="2">Fashioning on the shoulder shapes the curve for the cap sleeve (image 2.1.2). Image (2.1.3) shows the raglan armhole shaping</td></tr>
<tr><td colspan="2"></td></tr>
<tr><th colspan="2">Source of image</th><td>Photograph taken by the researcher on KM2 premises</td></tr>
</table>

Table 7.8 Garment observation KM1.1 details

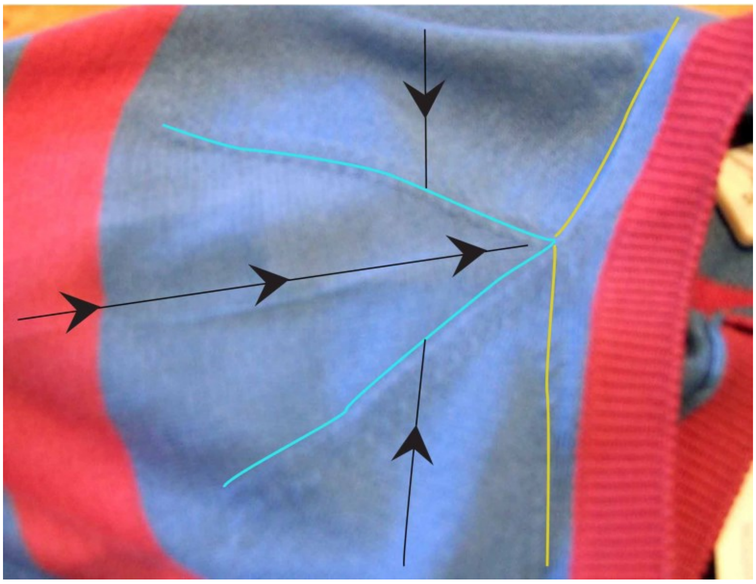
Garment KM2.1 showing details of shaping,	 Image 2.1.4
Indicates shaping line (narrowing and widening)	
Indicates where the sleeve and the body portion have been joined.	
Indicates the direction of the courses	
	 Image 2.1.5
Source of Image	Photograph taken by the researcher on KM2 premises

Table 7.9 Garment observation KM2.2 rib waist dress

Company	
KM2	
Garment code & description	
Rib waist dress (KM2.2)	
Range	**Size**
Spring 2007	M
Knit structure	
Plain body and sleeve. Rib waistband	
Innovation	
Seamless garment structure.	
Shaping	 Image 2.1.2
Waist shaping and fit achieved through utilisation of differing knit structures (image 2.1.2). Seamless set in sleeve.	
 Image 2.1.3	
Source of image	Photograph taken by the researcher on KM2 premises

Table 7.10 Garment observation KM2.3 Rib waist top

<table>
<tr><th colspan="2">Company</th><td rowspan="11">
Image 2.3.1</td></tr>
<tr><td colspan="2">KM1</td></tr>
<tr><th colspan="2">Garment code & description</th></tr>
<tr><td colspan="2">Rib waist top (KM2.3)</td></tr>
<tr><th>Range</th><th>Size</th></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><th colspan="2">Knit structure</th></tr>
<tr><td colspan="2">Pointelle sleeve and upper bodice.
Rib waist and welt</td></tr>
<tr><th colspan="2">Innovation</th></tr>
<tr><td colspan="2">Seamless garment structure. The change between knit structure is also seamless</td></tr>
<tr><th colspan="2">Shaping</th></tr>
<tr><td colspan="2">A ribbed lower bodice is shaped to an under bust point creating a feminine garment shape (Image 1.3.2) The sleeve has seamless set in shaping.</td><td>
Image 1.3.2</td></tr>
<tr><th colspan="2">Source of image</th><td>Photograph taken by the researcher on KM2 premises</td></tr>
</table>

Table 7.11 Garment observation KM2.4 V neck top

<table>
<tr><td colspan="2">Company</td><td rowspan="14">
Image 2.4.1</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><td colspan="2">Garment code & description</td></tr>
<tr><td colspan="2">V neck top (KM2.4)</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><td colspan="2">Knit structure</td></tr>
<tr><td colspan="2">Plain body and sleeves
Rib neckband and cuffs</td></tr>
<tr><td colspan="2">Innovation</td></tr>
<tr><td colspan="2">innovative armhole shaping (Image 2.4.2).
Seamless structure</td></tr>
<tr><td colspan="2">Shaping</td></tr>
<tr><td colspan="2" rowspan="3">The armhole has been shaped as a zigag (Image 2.4.2). The body is loose fitting. The neckband and cuffs have been linked as a separate post-production operation.</td></tr>
</table>

<table>
<tr><td></td><td>
Image 2.4.2</td></tr>
<tr><td>Source of image</td><td>Photograph taken by the researcher on KM2 premises</td></tr>
</table>

Table 7.12 Garment observation KM2.5 tie front top

<table>
<tr><th colspan="2">Company</th><td rowspan="10">
Image 2.5.1</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><th colspan="2">Garment code & description</th></tr>
<tr><td colspan="2">Tie front top (KM2.5)</td></tr>
<tr><th>Range</th><th>Size</th></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><th colspan="2">Knit structure</th></tr>
<tr><td colspan="2">Plain</td></tr>
<tr><th colspan="2">Innovation</th></tr>
<tr><td colspan="2">The garment has been knitted horizontally, not vertically.</td></tr>
<tr><th colspan="2">Shaping</th><td rowspan="3">

Image 2.5.2</td></tr>
<tr><td colspan="2">There is a visible fashioning line (Image 2.5.2 & 2.5.3)</td></tr>
<tr><td colspan="2">
Image 2.5.3</td></tr>
<tr><th colspan="2">Source of image</th><td>Photograph taken by the researcher on KM2 premises</td></tr>
</table>

Table 7.13 garment observation KM2.6 zigzag armhole

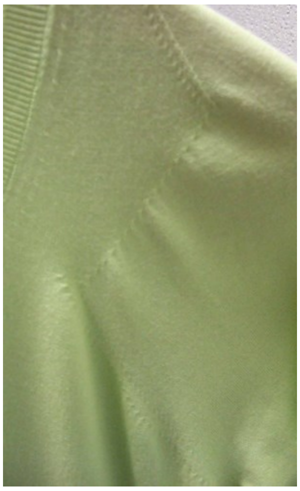
<table>
<tr><td colspan="2">Company</td><td colspan="2" rowspan="12">
Image 2.6.1</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><td colspan="2">Garment code & description</td></tr>
<tr><td colspan="2">zigzag armhole T shirt (KM2.6)</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><td colspan="2">Knit structure</td></tr>
<tr><td colspan="2">Plain body and sleeves
rib neckband cuff and welt</td></tr>
<tr><td colspan="2">Innovation</td></tr>
<tr><td colspan="2">Innovative armhole shaping (Image 2.6.2)</td></tr>
<tr><td colspan="2">Shaping</td></tr>
<tr><td colspan="2" rowspan="2">Image</td></tr>
<tr><td>
Image 2.6.2</td><td>
Image 2.6.3</td></tr>
<tr><td colspan="2">Source of image</td><td colspan="2">Photograph taken by the researcher on KM2 premises</td></tr>
</table>

Table 7.14 garment observation KM2.7 balloon top

<table>
<tr><td colspan="2">Company</td><td rowspan="12">
Image 2.7.1</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><td colspan="2">Garment code & description</td></tr>
<tr><td colspan="2">Balloon top (KM2.7)</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><td colspan="2">Knit structure</td></tr>
<tr><td colspan="2">Plain body and sleeves, rib neckband, cuff- and welt</td></tr>
<tr><td colspan="2">Innovation</td></tr>
<tr><td colspan="2">Innovatively shaped knitted garment supplied with a knitted belt (Image 2.7.1)</td></tr>
<tr><td colspan="2">Shaping</td></tr>
<tr><td colspan="2">Fashioning on the lower half of the garment produces a curved side seam creating the balloon shaping (Image 2.7.2). The sleeves are seamless and set in</td></tr>
<tr><td colspan="2"></td><td>
Image 2.7.2</td></tr>
<tr><td colspan="2">Source of image</td><td>Photograph taken by the researcher on KM2 premises</td></tr>
</table>

Table 7.15 Garment observation KM2.8 balloon skirt

<table>
<tr><td colspan="2">Company</td><td colspan="2" rowspan="11">
Image 2.8.1</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><td colspan="2">Garment code & description</td></tr>
<tr><td colspan="2">balloon skirt (KM2.8)</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><td colspan="2">Knit structure</td></tr>
<tr><td colspan="2">Plain body, rib welt</td></tr>
<tr><td colspan="2">Innovation</td></tr>
<tr><td colspan="2">Innovative garment shaping created by integral shaping.</td></tr>
<tr><td colspan="2">Shaping</td></tr>
<tr><td colspan="2">Shape created by integral fashioning in towards the hem of the garment. Image 2.8.2 shows half the skirt. Image 2.8.3 & 2.8.4 show the integral fashioning undertaken to create the curved shape</td><td>

Image 2.8.2</td><td>
Image 2.8.3

Image 2.8.4</td></tr>
<tr><td colspan="2">Source of image</td><td colspan="2">Photograph taken by the researcher on KM2 premises</td></tr>
</table>

Table 7.16 Garment observation KM2.9 drape top

<table>
<tr><td colspan="2">Company</td><td colspan="2" rowspan="12">
Image 2.9.1</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><td colspan="2">Garment Description & code</td></tr>
<tr><td colspan="2">Drape side balloon top (KM2.9)</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>spring 2008</td><td>Small</td></tr>
<tr><td colspan="2">Knit Structure</td></tr>
<tr><td colspan="2">Pointelle body, pointelle sleeves. Rib cuffs and welt</td></tr>
<tr><td colspan="2">Special feature</td></tr>
<tr><td colspan="2">The top is shaped to create a 3D shape that should fall in drapes at the side. A button neck placket which has been applied as a post-production operation</td></tr>
<tr><td colspan="2">Shaping</td></tr>
<tr><td colspan="2">An integral shaping line has been incorporated on the back and the front of the garment help create the draped shape. Further shaping is created on the lower half of the body to create the balloon shape. The sleeves are set in with a dropped shoulder line at the back.</td></tr>
<tr><td colspan="2">Other comments</td><td rowspan="2">Source of image</td><td rowspan="2">Photograph taken by the researcher of garment purchased from KM2</td></tr>
<tr><td colspan="2">This top is a good example of a garment that has been constructed to create a 3D shape and then pressed flat (Image 2.9.3)</td></tr>
</table>

Table 7.17 Details of garment KM2.9

<table>
<tr><td colspan="2">Company</td><td rowspan="9">
Image 2.9.2

Image 2.9.3</td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><td colspan="2">Garment Description</td></tr>
<tr><td colspan="2">Drape side balloon top KM2.9</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>spring 2008</td><td>Small</td></tr>
<tr><td colspan="2">Knit Structure</td></tr>
<tr><td colspan="2">Plain body, pointelle sleeves
Rib cuffs and welt</td></tr>
<tr><td colspan="2">Details of Special feature</td></tr>
<tr><td colspan="2" rowspan="2">Image 2.9.2 shows the button neck garment feature which has a rib neckband which has been linked on and a placket which has been sewn. The button holes are also sewn.

Image 2.9.3 shows that the garment is made as a 3 dimensional shape creating a drape affect falling diagonally towards the hem line both sides of the garment. The box has been placed on the image to highlight the crease which has been formed during the pressing process.</td><td></td></tr>
<tr><td>Source of image: Photograph taken by the researcher of garment purchased from KM2</td></tr>
</table>

Table 7.18 Details of garment KM2.9

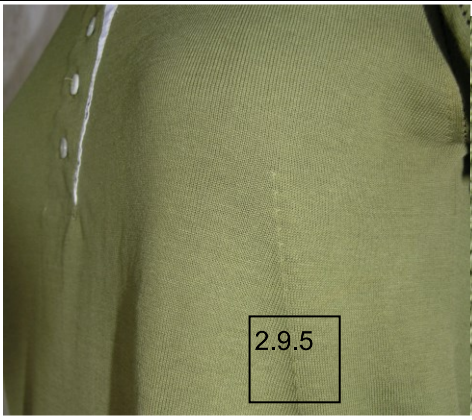
<table>
<tr><td colspan="2">Company KM2</td><td colspan="2">Garment description Drape side balloon top KM2.9</td></tr>
<tr><td colspan="4">Shaping details</td></tr>
<tr><td colspan="4">Image 2.9.4 shows the integral shaping line used to widen the garment which runs from just under the bust to just above the pointelle pattern (Image 2.9.6 and 2.9.7)</td></tr>
<tr><td colspan="3">

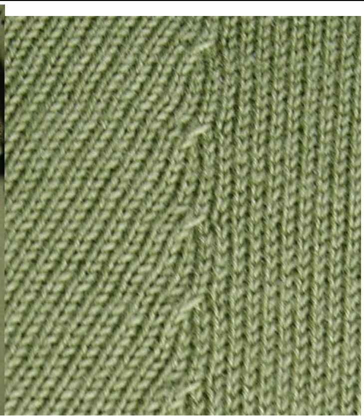
Image 2.9.4 
Image 2.9.5</td><td rowspan="2">Image 2.9.5 shows a close up of the widening line and it is clear that every three courses become one. The image reveals that it is only the courses on the left side of the shaping line that are lost. The courses on the right hand side remain constant.

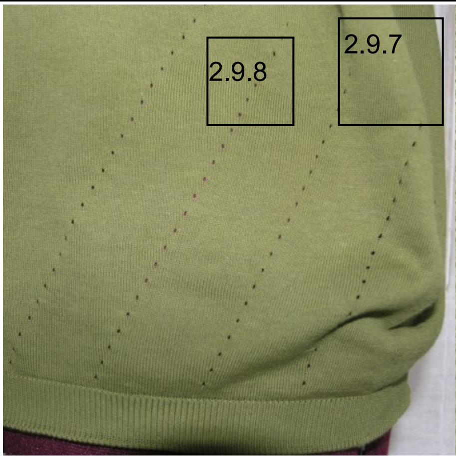
Image 2.9.8 shows that more narrowing occurs running into the pointelle pattern Image 2.9.7 shows the shape of the garment at the bottom of the shaping line</td></tr>
<tr><td colspan="3">

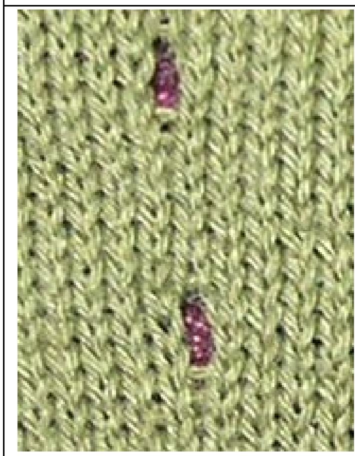
Image 2.9.6 
Image 2.9.7</td></tr>
<tr><td rowspan="2">
Image 2.9.8</td><td rowspan="2">
Image 2.9.9</td><td colspan="2">
Image 2.9.10</td></tr>
<tr><td colspan="2">Image 2.9.9 & 2.9.10 show the inset sleeve, which has a shoulder line, dropped towards the back.</td></tr>
</table>

Table 7.19 Garment observation KM2.10 stripe top

<table>
<tr><th colspan="2">Company</th><td colspan="2" rowspan="8"></td></tr>
<tr><td colspan="2">KM2</td></tr>
<tr><th colspan="2">Garment description</th></tr>
<tr><td colspan="2">KM2.10</td></tr>
<tr><th>Range</th><th>Size</th></tr>
<tr><td>Spring 2007</td><td>M</td></tr>
<tr><th colspan="2">Knit structure</th></tr>
<tr><td colspan="2" rowspan="2">Plain body and sleeves Rib neckband Cuff and welt</td></tr>
<tr><th>Source of image</th><td>Photograph taken by the researcher on KM1 premises</td></tr>
<tr><th colspan="2">Special feature</th><td colspan="2" rowspan="7"></td></tr>
<tr><td colspan="2">Unbroken stripes running around the neckline (Image 1)</td></tr>
<tr><td colspan="2">shaping</td></tr>
<tr><td colspan="2">Seamless raglan, cap sleeve (Image 2)</td></tr>
<tr><td colspan="2">Other comments</td></tr>
<tr><td colspan="2">The neckband and armhole rib are knitted separately and linked on as a post-production procedure (Image 2)</td></tr>
</table>

Table 7.20 Garment observation KM2.11 Asymmetric top

Company			
KM2			
Garment description			
Asymmetric top KM3.11			
Range	Size		
Spring 2007	M		
Knit structure			
Plain body and sleeves, rib cuffs, welt and neck band			
Special feature			
Both side seams curve in the same direction. One side of the garment is longer than the other.			
shaping		Source of image	Photograph taken by the researcher on KM1
Seamless set in sleeve			
Other comments			
The neckband is knitted separately and linked on as a post-production procedure			

Table 7.21 Garment observation KM2.12 Balloon sleeve top

Company		 Image 1	
KM2			
Garment description			
Balloon sleeve top KM2.12			
Rang	Size		
Spring 2007	M		
Knit structure			
Plain body and sleeves and rib cuffs and neck and hemline			
Special feature			
The sleeves are an exaggerated balloon shape that forms a point at the widest part (Image 2). The cuffs are extremely long. The ribbed cuffs and hemline create gathering (Image 1).			
shaping		Image 2	
The sleeve is fashioned to create the balloon shaping. The armhole is seamless set in (Image 2).			
Other		**Source of images**	Photograph taken by the researcher on KM1 premises
The neckband is knitted separately and linked on as a post-production procedure			

7.5.3 Analysis of specification documents: KM2

The specification document from KM2 (1.1.1.1Appendix F p309) detailed the dimensions of a long sleeved shirt. Five sizes are specified. All the dimensions relate solely to garment measurement and no relative body dimensions are included. 15 dimensions are used to define the garment. The document includes terminology that is not commonly used, top of basque for instance is 2cm smaller in dimension than the chest measurement. No further explanation to clarify this term is included and it does not appear on the technical drawing that accompanied the document. Further scrutiny suggests it represents the width between the underarm points. The measurement waist to top is 21cm shorter than the length of the garment and is not specified on the technical drawing, but appears to correspond to the garment length up to the underarm point. A full measurement for the armhole depth is not provided. The measurement specified refers to the lower portion of the armhole only. The technical drawing indicates that this is where the fashioning occurs. It is not specified how the shoulder slope from the side neck point is defined. The specification documents do not include all the dimensions necessary to define the garment. Further calculations must be made to determine the distance between the top of the fashioning points and the shoulder point on the body and the angle of the fashioning line on the sleeve which should also determine the overarm length. These measurements are for a women's garment, yet a chest dimension is defined, not a bust dimension. The grading increments between the garment chest sizes are 6cm which is indicative of the change in grading practices described in the interviews. Table 7.22 summarises the details from the KM1 specification documents.

Table 7.22 Details from KM2 specification document

KM2 Garment specification analysis		**Total**
Garment	Long sleeve shirt	NA
Size code	Descriptive (SML, MED, LGE, XLG, XXL)	5
Garment dimensions specified	Chest width, Body length (including welt), Sleeve length (including welt), Sleeve at widest, Top of basque, Across front fashion point, Top of shoulder width, Waist width, neck drop, Cuff width, Rib depth neck, Armhole	15
Body dimensions specified	None	0
Grading increment cm	Half chest 3, Length 2, Shoulder 1.5, Waist 3	6,2,1.5 6

7.6 case study 3: (KM3): Company History

KM3 define themselves as a knitwear company with a heritage, claiming to have over a hundred years of cashmere knitting experience dating back to 1874. Originally a hosiery producer they changed their name and focus in 1990, whilst remaining in their original factory premises. KM3 also promote their use of new technology and its ability to create new design possibilities within their marketing material. They implemented complete garment technology in 2002. As a Scottish luxury knitwear producer they acknowledge the need to minimise the impact of cheap imported cashmere products (Mowbray 2005c). The primary reason for utilisation of complete garment machinery was that it enabled them to remain competitive. KM3 currently operate an online store as well as eleven high street stores, seven of which are in the UK. As KM3 do not employ a permanent designer it was not possible to gain perspective on practices from the designer's point of view.

7.6.1 Garment innovation

KM3 were particularly keen to maintain their luxury status and the production of fully fashioned garments was perceived to be integrally bound up with notions of status. The inclusion of clearly visible fashioning marks was therefore considered highly important at KM3. This did not prevent them from also pursuing methods to innovate and the interview analysis revealed that innovative shaping had been successfully developed. This included voluminous garments with the wales running horizontally, puffball shapes with sophisticated integral shaping techniques and a number of integral trims. A crossover cardigan was in development. KM3 also used shaping techniques particularly suited to the tubular structure of complete garments, such as yokes and parachute shaping that integrally narrows and shapes the shoulders and neck. Influences had also been taken from the machine builder's sample garments. The process of product development was reliant on the adaptation of successful garment templates to create new styles, saving programming time at the development stage. Since complete garment technology had been implemented the range of garment styles had increased, novel examples included trousers, capes and dresses. Rib knit structures that stretch and recover had been exploited to create waistbands on trousers and shorts and create shape at the waist of a tunic. A yarn with a small percentage of lycra was used for the integral ribs to increase their capacity to stretch and recover. Analysis of the garment observation revealed that narrowing and widening was used predominantly to create neck and armhole shaping. Parachute shaping had been used to create a streamline narrowing at the neckline and shoulders (Table 7.27 p171 Table 7.37 p181).

To satisfy their international customer, KM3 had introduced new fibres such as cotton and silk and were experimenting with finer gauge machines to produce cooler garments for hotter climates. KM3 had also introduced a service offering limited customisation to individual customers. This was only possible through utilisation of complete garment technology and the flexibility of production it provided. In terms of fit The seamless aspect of complete garments was identified as a fit improvement, particularly for garments worn next to the skin.

7.6.2 Restrictions to innovation

KM3, do occasionally still used some postproduction processes, such as linking on neckbands. With regards to shaping limitations it had been found that in comparison the Cotton Patent machinery, the degree of acuteness to which angles could be achieved was restricted on complete garment technology. This limitation was acknowledged to cause difficulties when shaping the bust and the armhole. There was plenty of evidence from the case study to show that the pressing process was considered integral both to the maintenance of dimensional stability and to the quality of the finished garments. KM3 were producing cashmere and the use of steam, which is integral to the pressing process, was credited with increasing the softness of the fibres. Equally important was the notion that pressing the garment sets the size and shape and that length can be reduced if the width is increased or vice versa. All the garments at KM3 were pressed on boards after they had been washed. At the end of the process a Hoffman press, which presses garments flat between two heated plates is used. No comments were made reflecting changing demands in relation to pressing and utilisation of complete garment technology, however if the complex puffball garments mentioned by KM3sales were structured three dimensionally, a Hoffman press would be an unsuitable tool to use.

7.6.3 Role disparities within product development

Analysis of the data from KM3 revealed that it was considered important to invest in an extensive training programme for the technicians to transfer their skill set from fully fashioned panel development on Cotton Patent machinery to programming for complete garment technology. KM3tec had attended two training courses at Shima Seiki in Japan. Language and cultural barriers were listed as factors that had made this training experience difficult. Technicians from Shima Seiki’s UK office had also spent a considerable amount of time training personnel on KM3 premises and they were still visiting them on a weekly basis. KM3 claimed to be the first company to commercially knit complete garments using cashmere yarn. The fragility of the yarn had initially caused frequent breakages. The impact of this problem was limited by the selection of a suitable yarn density and ensuring that the machines were specifically set up for cashmere. The technicians appeared to be the key decision makers in regards to how and which garments were developed and they also attended the fit trials. The technical team were encouraged to feel like they were part of the design team and to take an experimental approach which had been found to help develop their skills and understanding. Japanese working practices had been implemented at KM3 and the product development process had subsequently become more collaborative between all members of the team.

The technician acknowledged that having to conceptualise the 3D garment was challenging, particularly for inexperienced personnel. Joining the body and sleeves whilst creating acceptable fit and ensuring that the component parts of the garment are of equal dimension were all identified as intellectually arduous tasks that the technician is solely responsible for. Programming, it was admitted, could be extremely laborious, with prototype garments taking between 4 to 39 hours to complete. It was however claimed that new software developments from the machine builders were helping to reduce programming times along with some of the difficulties associated with the programming process.

KM3 did not employ a full time designer but used freelance designers. A Japanese designer, who could consult directly with Shima Seiki technicians, had specified designs that challenged the technicians to create complex garment programs. This was acknowledged to have increased their ability to exploit the machine capability and expand the product range. A European designer employed during the study was valued for her ability to create complex knit structures. Analysis of the interview data provided no evidence to suggest that training on complete garment technology was deemed to be necessary for the designers. Perhaps as a result of the lack of training and investment in design skills, inappropriate design specifications had been abandoned at prototype stage. It was however accepted that an experimental approach to develop new design ideas sometimes led to failed attempts but the experience of working with the technology was steadily developing the designers' skills.

7.6.4 Anthropometric data deficiency

There was no evidence to suggest KM3 use anthropometric data when determining the dimensions of their prototype garments or their garment grading. All the data used clearly related to garment dimension. It was considered to be the technician's role to interpret the garment measurement data specified by the designer. The data revealed this often entailed modification of the designer's specification which may subsequently change the designer's original concept. Analysis of the interview data shows that the technicians were striving to ensure that the component parts of the garment join in a satisfactory manner, yet they do not consider the complex nature of the female body. The technicians also translate the specified measurement dimension to stitch density using a tube of fabric on which to base the evaluation. The pressing process was acknowledged to be influential on garment dimension and all the garments have their size dimensions attached when they are sent to be pressed. The garment is re-measured when it returns from the press.

Trading internationally was acknowledged to influence the sizing demands however, KM3 did not have international anthropometric data available to support informed decisions regarding this issue.

At KM3 it was recognised that consumers from different regions of the world differ in size and that fit preferences are likely to vary from those in the UK. However no international sizing standards had been located on which to inform their practicies. In relation to garment fit KM3 vary the actual dimensions of sized garments depending on the way the garment is intended to fit the body (degree of looseness). KM3 used more than one system of size coding on their garments. Most were coded using single numeric however the largest sizes were coded descriptively (XXL). In the KM3 factory however, an outdated system of using bust measurement in inches to identify garment size is used. There was no acknowledgement of differing demands regarding size coding for an international market. Quality issues were also a priority because it was acknowledged that customers investing in expensive garments had high expectations. Achieving satisfactory garment fit was integral to satisfying these high expectations. Garment fit at KM3 was claimed to be constantly updated in line with fashion expectations.

7.6.5 Approximate fit practices

Interview data analysis revealed new prototype garments are not expected to conform to specified dimensions and it is the fit trial that determines the correct garment proportions. Garment dimension is considered to be unstable and malleable during the manufacturing processes. Methods used were clearly experimental and incorporated a high degree of trial and error. Perhaps not surprisingly it could take as many as three attempts before fit satisfaction was achieved. The technician's comments reveal that because there are so many unknown factors within the development process, such as tension differences, which can influence garment size, results are difficult to predict. Pressing and washing were also acknowledged to influence dimensional change. The knit density cannot be changed but the garment can either be stretched across the courses decreasing the dimension down the wales or along the wales decreasing the dimension across the courses. The data analysis revealed an example of this malleability in description of how additional length was added to a garment to compensate for the inability to increase the width due to machine limitations. The approach to fit practices at KM3, acknowledges the difficulties of using precision when working with such a fluid material. With so many unexpected variables, there appeared to be an expectation for results to be haphazard and random. In addition the design specification were claimed to be inaccurate and need frequent modifications.

Members of the factory staff were used as fit models for fit trials and they are not measured before the trials. Knitted fabric must therefore accommodate a high degree of tolerance if these kinds of adjustments were deemed to be satisfactory. The unstable properties of a knitted fabric are built in to the tolerances used at KM3, which were high. Although the properties of differing knit structures were used to create fit, no system of evaluation was mentioned. KM3 produce three different garment shapes which conform to the body with varying degrees of looseness. Garment fit was constantly being updated and comments revealed that fashion changes the consumer's fit expectations regarding knitwear.

7.7 Garment Observation KM3: Analysis of findings

The photographs of the garments at KM3 were taken in the shop that is attached to their manufacturing premises. Time was not restricted so it was possible to capture close up images of the garments. Examination of the stitch formation within the knit structures was therefore possible.

7.7.1 Knit structure

The garments from KM3 were manufactured using a variety of knit structures. Eight out of the 12 garments analysed were constructed in plain knit, two of which were completely plain knit and five either had integrally knitted rib or purl neck trims and cuffs. Two of the garments were knitted in rib. One was a 1x1 rib, one a 4x4 rib with a 2 x.2 waist band. One garment was a cable knit and one a honeycomb knit structure reminiscent of patterns used for Aran sweaters.

7.7.2 Shaping and Innovation

The KM3 garment observations show that a variety of armhole and sleeve shaping has been used. Traditional shaping, raglan, saddle and set in sleeves were prevalent amongst the KM3 garments but a number of garments were manufactured using techniques developed through the utilisation of complete garment technology namely, yokes and seamless gathered sleeve heads.

Table 7.23 KM1 Garment observation: armhole and sleeve shaping

KM3 garment	Armhole shape	Total no. of garments
KM3.1, KM3.11	Raglan armhole into a yoke	2
KM3.2, KM3.6, KM3.9	Set in sleeve	3
KM3.3, KM3.5, KM3.8, KM3.9, KM3.12	Raglan sleeve	5
KM3.4	Set in sleeve with gathered sleeve head	1
KM3.7	Saddle shoulder armhole	1

Analysis of the garment observation data from KM3 revealed that none of the garments had any shaping that conformed to the curvature of the female body such as bust waist and hips (Table 7.24 p168). Although the actual shape of the body section of the garment were predominantly all a basic tubular structure, there was a visible difference in the dimensions used which will change the way the garment fits the body. (All the garments selected were a size medium). Garment KM3.10 (Table 7.36 p180) for instance, is narrow in the body without any visible curvature but would mould to the body curvature. KM3.1 (p171), KM3.2 (p172), KM3.3 (p173) and KM3.9 (p179) are made to drape over the body. Garments KM3.5 (p175), KM3.6 (p176), KM3.7 (p177) and KM3.11 (p181) are semi fitted garments but still have no evident waist or bust shaping. The only garment that had any waist shaping was KM3.12 (p182) which was created by placing a wide band of rib knit structure at the waist (Figure 3.12.2 Table 7.38 p182).

Table 7.24 KM3 garment observation: body shape

KM3 Garment	Body shape
KM3.1, KM3.2, KM3.4, KM3.9	Long loose tunic (no evident shaping for bust waist or hips)
KM3.5, KM3.7, KM3.11	Short loose tunic (no evident shaping for bust waist or hips)
KM3.8, KM3.10	Slim tunic (no evident shaping for bust waist or hips)
KM3.6	Short fitted with ribbed waistband
KM3.12	Long tunic shape with slightly shaped rib waist
KM3.3	Long tunic shaped body edged with a rib band to create a garment that is loose around the body, but hugs the thighs(no evident shaping for bust waist or hips)

The results from Table 7.25 indicate that KM3 produced a broad range of neck shapes utilising a variety of methods to construct these. There are several instances of innovative neck shaping methods. The ability to knit the shoulder and neck within a yoke, for instance, is particularly suited to complete garment manufacturing. This shaping method takes, as the initial conceptual premise, that the garment is tubular and three dimensional. It does not try to replicate traditional techniques of shaping, developed for producing knitted panels which work with 2D shapes. A number of the garments had integral features, such as buttonholes and neckbands. There were also a number of examples of neck trims that had been applied using post-production operations.

Table 7.25 KM3 garment observation: neck shapes

KM3 garment	Neck shape	Method of construction
KM3.1, KM3.7,	Shallow round neck	Integral yoke (parachute shaping)
KM3.8	Shallow round neck	Integral neckband
KM3.11	Shallow round neck	Neckband applied post-production.
KM3.4	Slightly scooped neck	Integrally knitted purl neckband that curls back to form a rolled neckline
KM3.3	Cowl neck	Integrally knitted
KM3.2	Shallow button front V neck with keyhole opening and button	Integrally knitted neckband and buttonhole
KM3.5	Shallow round neck with keyhole opening and button	Integrally knitted neckband and buttonhole.
KM3.6	Hood	Hood attached post-production.
KM3.10	Collar and button stand	Not possible to discern method of construction
KM3.9	Square neck	Integrally knitted rib neckband.
KM3.12	Roll neck	Integrally knitted

At KM3 the styling and shaping used reflected their traditional approach. Innovation was incorporated predominantly through the appliance of integral trims such as button hole and belt loops. The addition of hoods and parachute shaping to the garments are also examples of an innovative approach.

7.7.3 Analysis of KM3 specification document

The specification document provided by KM3 (1.1.1.1Appendix G p310) did not include a technical sketch. It was therefore difficult to make a thorough analysis of the information without the visual details. The size range covers 7 sizes all of which are coded as single numeric apart from the largest which is descriptive (Table 7.26). KM3 use 11 measurements to define this garment. The terminology for some of these measurements is obscure, they use 'knitting size' for instance to mean chest size. There is no reference to body measurement. The dimensions provided would not enable the garment to be programmed without further calculation. For instance although the armhole depth is defined, no measurement is provided that would define the shape of the armhole. There is also no specification of where the underarm point is in relation to the body. None of the measurement specified relates specifically to the female body.

Table 7.26 Details from KM3 garment specification document

KM3 Garment specification analysis		Total
Garment	Slightly waisted jumper	NA
Size code	Single numeric (1, 2, 3, 4, 5, 6) & descriptive (XXL)	7
Garment dimensions specified	Knitting size, Body length, Sleeve length (under and over arm), Armhole depth, Shoulder width, Waist, Skirt width, Muscle, Lower arm, Cuff width, Back neck	11
Body dimensions specified	None	0
Grading increment cm	Knitting size (chest)	4-6
	Length	1-2
	Shoulder	1-2
	Waist	4-6

Table 7.27 Garment observation KM3.1 Striped jumper

Company	KM3
Garment code & Description	Striped sweater (KM3.1)
Range	**Size**
spring 2008	medium
Knit Structure	1x1 rib
Innovation	Yoke neckline. Unbroken stripes around the circumference of the garment.
Shaping	Integral neckline with parachute (integral) to shape the neck and shoulders, raglan shaped sleeve

Image 3.1.1


Image 3.1.3


Image 3.1.4


Image 3.1.2

Source of images	Photographs taken by the researcher in a KM3 retail outlet

Table 7.28 Garment observation KM3.2 top with integral buttonhole

<table>
<tr><th colspan="2">Company</th><td rowspan="13">

Image 3.2.1


Image 3.2.2 Image 3.2.3</td></tr>
<tr><td colspan="2">KM3</td></tr>
<tr><th colspan="2">Garment code & Description</th></tr>
<tr><td colspan="2">Striped sweater (KM3.2)</td></tr>
<tr><th>Range</th><th>Size</th></tr>
<tr><td>spring 2008</td><td>medium</td></tr>
<tr><th colspan="2">Knit Structure</th></tr>
<tr><td colspan="2">Plain knit and 1x1 rib.</td></tr>
<tr><th colspan="2">Innovation</th></tr>
<tr><td colspan="2">Long rib cuffs, integral neck line and button hole. Seamless change of knit structure (plain to rib)</td></tr>
<tr><th colspan="2">Shaping</th></tr>
<tr><td colspan="2">The neckline is integrally shaped. the sleeves are set in, no fashioning marks are visible</td></tr>
<tr><td colspan="2">
Image 3.2.4

Image 3.2.5</td></tr>
<tr><th colspan="2">Source of images</th><td>Photographs taken by the researcher in a KM3 retail outlet</td></tr>
</table>

Table 7.29 Garment observation KM3.3 cowl neck jumper

<table>
<tr><th colspan="2">Company</th><td rowspan="13">

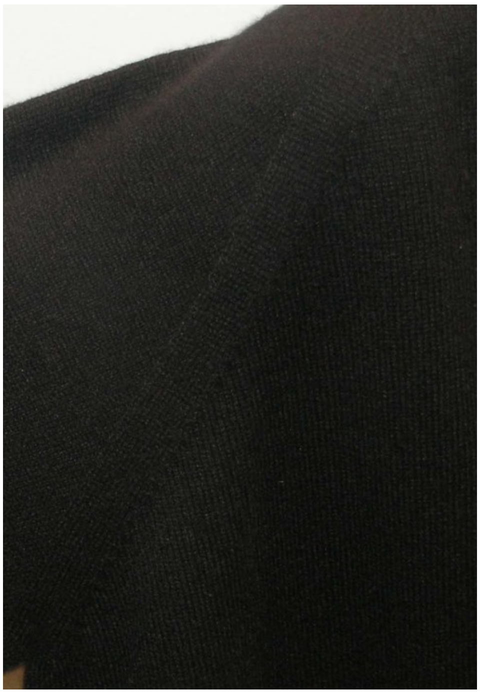
Image 3.3.1</td></tr>
<tr><td colspan="2">KM3</td></tr>
<tr><th colspan="2">Garment code & Description</th></tr>
<tr><td colspan="2">Scoop roll neck sweater (KM3.3)</td></tr>
<tr><th>Range</th><th>Size</th></tr>
<tr><td>spring 2008</td><td>medium</td></tr>
<tr><th colspan="2">Knit Structure</th></tr>
<tr><td colspan="2">Plain knit body 2x2 rib neck, cuff and welt</td></tr>
<tr><th colspan="2">Innovation</th></tr>
<tr><td colspan="2">The seamless structure, clean armholes and neckline. Seamless change of knit structure at neck, hem and cuff.</td></tr>
<tr><th colspan="2">Shaping</th></tr>
<tr><td colspan="2">Raglan shaped sleeve (Image 2).</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2" rowspan="2">
Image 3.1.2</td><td></td></tr>
<tr><td>
Image 3.1.4</td></tr>
<tr><th colspan="2">Source of images</th><td>Photographs taken by the researcher in a KM3 retail outlet</td></tr>
</table>

Table 7.30 Garment observation KM3.4 puff sleeve jumper

Company

KM3

Garment code & Description

Tunic with gathered sleeve head. (KM3.4)

Range	Size
spring 2008	medium

Knit Structure

Plain knit, 1x1 cuff

Innovation

Gathered sleeve head which is knitted as an integral feature of the complete garment (Image 3.4.2)

Shaping

The sleeve is shaped predominantly by a long rib cuff. The neckline shape is created by narrowing towards the shoulder and the incorporation of differing knit structure around the neck exploits the propensity of a plain knitted structure to roll

Image 3.4.3

Source of images
Photographs taken by the researcher in a KM3 retail outlet

Image 3.4.1

Image 3.4.2

Table 7.31 Garment observation KM3.5 top with integral button loop

Company	
KM3	
Garment & code Description	
Button neck sweater (KM3.5)	
Range	**Size**
spring 2008	medium
Knit Structure	
Plain knit	
Innovation	
The button loop has been constructed integrally and the neck shaping, including a keyhole opening is also integral (Image 3.5.3).	
Shaping	
Raglan shaped sleeve with clear fashioning marks on the body where the fabric has been narrowed. The neck is also integrally shaped and finished integrally	

Image 3.5.3

Image 3.5.1

Image 3.5.2

Source of images	Photographs taken by the researcher in a KM3 retail outlet

Table 7.32 Garment observation KM3.6 hooded top

Company		
KM3		
Garment code & Description		
Hooded top (KM3.6)		
Range	**Size**	
spring 2008	medium	
Knit Structure		
Plain knit, 1x1 rib cuffs and welt		
Innovation		
Knitted hood linked to the garment. Zip front is also applied as a post-production operation.		
Shaping		
The sleeves are set in and show fashioning marks where they have been narrowed to at the shoulder. The shoulder seam however is linked as a post-production operation.		

Image 3.6.1

Image 3.6.2


Image 3.6.3


Image 3.6.4

Source of images	Photographs taken by the researcher in a KM3 retail outlet

Table 7.33 Garment observation KM3.7 cable sweater

Company	
KM3	
Garment code & Description	
Saddle sleeve cable sweater (KM3.7)	
Range	**Size**
spring 2008	medium
Knit Structure	
Cable and 4x2 rib, 1x1 rib cuffs. 2x2 rib neckband	
Innovation	
The knit structure has been created to fit the saddle shoulder line using mini cables as a feature (Figure 3.7.3).	
Shaping	
Armhole - fashioning marks evident where the body narrows to the shoulder. The neckline has been cut and the neck band linked on in post-production	
 Figure 3.7.3	
Source of images Photographs taken by the researcher in a KM3 retail outlet	

Figure 3.7.1


Figure 3.7.2

Table 7.34 garment observation KM3.8 honeycomb sweater

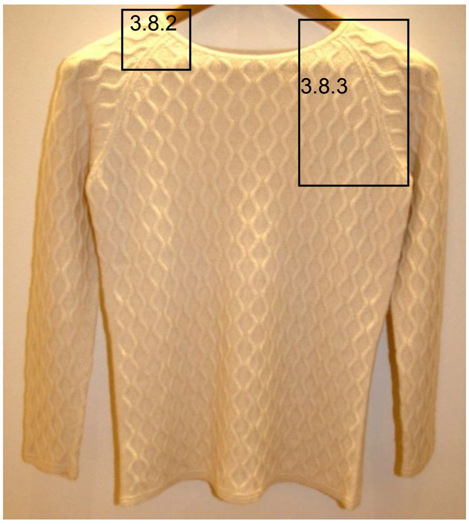
<table>
<tr><td colspan="2">Company</td><td rowspan="12">

Image 3.8.1

Image 3.8.2</td></tr>
<tr><td colspan="2">KM3</td></tr>
<tr><td colspan="2">Garment code & Description</td></tr>
<tr><td colspan="2">Honeycomb jersey (KM3.8)</td></tr>
<tr><td>Range</td><td>Size</td></tr>
<tr><td>spring 2008</td><td>medium</td></tr>
<tr><td colspan="2">Knit Structure</td></tr>
<tr><td colspan="2">Honeycomb knit structure (used in Aran sweaters). Purl neck band, cuff and hem.</td></tr>
<tr><td colspan="2">Innovation</td></tr>
<tr><td colspan="2">The honeycomb knit structure is the main feature of this garment.</td></tr>
<tr><td colspan="2">Shaping</td></tr>
<tr><td colspan="2">The neckline is integrally shaped (Image 3.8.2).
Raglan shaped sleeve (Image 3.8.3)

Figure 3.8.2</td></tr>
<tr><td colspan="2">Source of images</td><td>Photograph taken by the researcher in a KM3 retail outlet</td></tr>
</table>

Table 7.35 Garment observation KM3.9 double breasted tunic

Company	
KM3	
Garment code & Description	
Double breasted cardigan (KM3.9)	
Range	**Size**
spring 2008	medium
Knit Structure	
Plain knit body, purl button stand, cuff edge and hem, Integral rib neckband	
Innovation	
Square neck line, double breasted buttoned neck line. Three quarter length sleeves.	
Shaping	
Set in sleeves with fashion marks visible on the underarm. The button holes are stitched as a post-production operation	

Image 3.9.1


Image 3.9.2

Source of images	Photograph taken by the researcher in a KM3 retail outlet

Table 7.36 Garment observation KM3.10 tunic with collar

<table>
<tr><th colspan="2">Company</th><td rowspan="13">

Image 3.10.1

Image 3.10.2</td></tr>
<tr><td colspan="2">KM3</td></tr>
<tr><th colspan="2">Garment code & Description</th></tr>
<tr><td colspan="2">Polo top (KM3.10)</td></tr>
<tr><th>Range</th><th>Size</th></tr>
<tr><td>spring 2008</td><td>medium</td></tr>
<tr><th colspan="2">Knit Structure</th></tr>
<tr><td colspan="2">Plain knit body and sleeve, 1x1 rib collar, cuff button stand and welt.</td></tr>
<tr><th colspan="2">Innovation</th></tr>
<tr><td colspan="2">Button neck shirt with a collar. It is not possible to ascertain whether the collar and button stand are linked on as a post-production operation but it is likely that it is.</td></tr>
<tr><th colspan="2">Shaping</th></tr>
<tr><td colspan="2">Raglan sleeves knitted with visible fashioning marks on the body where it has been narrowed towards the neck (Image 3.10.2).</td></tr>
<tr><td colspan="2"></td></tr>
<tr><th colspan="2">Source of images</th><td>Photograph taken by the researcher in a KM3 retail outlet</td></tr>
</table>

Table 7.37 Garment observation KM3.11 Stripe short sleeve top

Company	
KM3	
Garment code & description	
Striped short-sleeve top (KM3.11)	
Range	**Size**
spring 2008	medium
Knit Structure	
Plain knit	
Innovation	
Striped that remain unbroken around the circumference of the garment body and neck (Image 3.11.1).	
Shaping	
The neck is shaped integrally and there are two fashioning lines either side of the centre front. The sleeves are raglan with fashioning lines at the armhole (Image 3.11.2)	
Source of images	Photograph taken by the researcher in a KM3 retail outlet

Image 3.11.1


Image 3.11.2

Table 7.38 garment observation KM3.12 poloneck tunic

Company	
KM3	
Garment code & Description	
Rib dress (3.12)	
Range	**Size**
spring 2008	medium
Knit Structure	
4x2 rib changing to 2x2 rib at the waist (Image 3.12.2)	
Innovation	
Rib Roll neck, knitted as an integral part of the complete garment (Image 3.12.4).	
Shaping	
The change of knit structure at the waist line creates some shaping. A saddle shoulder line is shaped integrally maintaining the line of the ribs running up through the centre of the outer sleeve (Image 3.12.3).	
Source of images	Photograph taken by the researcher in a KM3 retail outlet

Image 3.12.1

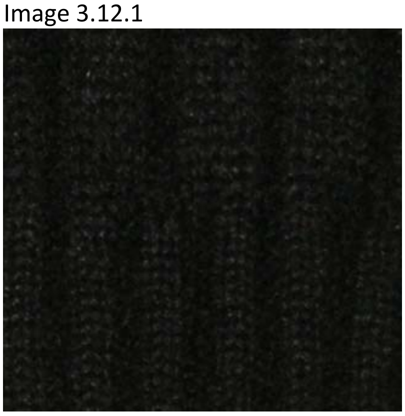


Image 3.12.2


Image 3.12.3


Image 3.12.4

7.8 Comparative analysis

The final stage of the case study analysis is a comparative analysis that codes the data to identify key similarities and differences between the case study companies in relation to their current size, fit and shaping practices.

7.9 Knitwear culture

Product development within all the case study companies involved a multi-disciplinary team with very clearly defined roles. The interviews confirmed that these roles had been originally defined by the development of the fully fashioned knitwear industry. The interview data analysis also indicated that fully fashioned knitwear was associated with notions of luxury, classic styles and a tendency towards conservatism. Each member of the product development team had to transfer skills and knowledge acquired through working on fully fashioned garments to the development of complete garments. The comparative data analysis provided an opportunity to evaluate how these changes had impacted on the two primary roles within the product development team, the designer and the technician.

7.9.1 The technician

All the technicians interviewed had formative experience within the fully fashioned knitwear industry and were male, none of the case study knitwear manufacturers employed female technicians. Two out of the three technicians interviewed (KM1tec and KM2tec) had formerly been employed by Shima Seiki UK. The technician's role was clearly considered to be pivotal to the product development process and an extensive period of training for the technical team was considered essential before utilisation of the technology was possible. There was overwhelming evidence, both from the interviews and the observational data to show the technicians were intellectually challenged by their new role. All the technicians acknowledged that the conceptualisation of the garment as a 3D structure, instead of a number of 2D garment panels presented a complex set of difficulties. The interview analysis revealed that the tubular garment structures were knitted on two opposing needle beds and maintaining an equal numbers of stitches on each needle bed was essential to prevent damages. It was common for the technicians to regard one needle bed for the front of the garment and the opposing bed for the back of the garment. It was also evident that the temptation for the technicians when regarding the knitting process within this format was to think of the front and back of the garment as two flat, equal panels and apply their fully fashioned knowledge to shape or fashion the edges of these panels. Analysis of the garment observations revealed this to be the case (Table 7.15 p154 Table 7.21 p166). There were also very clear examples of integral shaping (parachute shaping) used to shape the shoulders and the neck (Table 7.27 p171 & Table 7.37 p181) which narrows the tube evenly around its circumference and doesn't localise the fashioning at the edges of the back and the front of the garment. As well as more complex method that have created 3D elements with the tubular structure (Table 7.7 p146 & Table 7.16 p155). There is therefore clear evidence to show that it is possible to conceptualise and shape of the tubular structure integrally and consider as it a 3D object rather than two 2D panels.

The acute fashioning angles used to create the shape of the balloon sleeves (Image 2 Table 7.21 p166) had caused considerable production problems. However this is a prime example of shaping that has considered the tube as two flat panels and localised the fashioning at the edge. If this sleeve had been considered as a three dimensional tube and the fashioning had been applied equally around the circumference of the tube, the application of the extreme fashioning angles would not have been necessary and a more effective balloon shape would have been achieved. This example demonstrates very clearly the difficulties the technicians face when transferring one set of skills to a new method of working. This study reveals that conceptualising the complete garments requires a much more sophisticated knowledge of how to create 3D shape within the limitations of the knitting environment that is complete garment technology. This problem occurred when shaping was applied just to the sleeves, within this context it is easy to understand why the technicians all acknowledged that creating programmes that calculates how the sleeve tubes are joined to the body tube is particularly arduous. It was also evident that joining the sleeves to the body was the most difficult area of the garment to achieve. Analysis of the garment observations revealed that although innovative sleeve and armhole shaping was evident (Table 7.7 p146, Table 7.13 p152 & Table 7.27 p171), the most common shaping methods conformed to tradition styles such as set in and raglan sleeves.

Analysis of the interviews did provide evidence to show that although the technicians acknowledged that their shaping skills had a direct influence on garment fit the body was not referred to. The garment was discussed in relation to the needles, the machine functions and the knitted stitch but not to the body. Anthropometric data was only considered in the form of garment dimension, a chest measurement therefore referred to the dimension of the garment measured across the underarm point. The comparative analysis also revealed that the technicians all complained that the specifications provided by the designers did not provide enough accurate information and they frequently used their own experience to re-interpret the specifications provided. One comment indicated that having access to anthropometric data that related more directly to the methods used to develop complete garments would be beneficial. It was also evident that although the properties of differing knit structures were frequently exploited to create shape, no method to objectively evaluate these properties in relation to fit was conducted. The comparative analysis of the case study data clearly revealed that the technicians were instrumental in shaping the complete garment to create fit, yet understanding how to create 3D garment shapes with specific consideration of the female body was clearly not perceived to be integral to their role

7.9.2 The designers

The comparative analysis of the case study data revealed that all the designers of complete garments were female and were formally employed within the fully fashioned industry which clearly influenced their practice. It was also clearly evident that design skills were perceived to be transferable from fully fashioned knitwear to complete garment as no specific training was provided for the designers at any of the case study companies. This was a source of frustration for all those interviewed.

It was evident that the designers were primarily concerned with aesthetics and clearly this included the way the garment conformed to the female body. Analysis of the interview data revealed many references to the achievement of satisfactory fit on the body and acknowledgements that different consumers demanded a different type of fit. Fashion was also clearly influential and it was evident that even the designers within the classic and luxury knitwear companies felt that it was imperative to comply with trends. The design role therefore included a high degree of trend analysis. In terms of shaping, this evidently trend informed the designers' choice of garment silhouettes and the comparative analysis revealed that the designers at all three case study companies had explored puffball or draped silhouettes, which were fashionable at the time of this study. However, only KM2 and KM3 had achieved garments as a result of this exploration.

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. The analysis provides a number of examples to show

how the lack of specific knowledge and understanding restricts the designers' ability to design garments that improve fit and adhere to silhouettes that conform to trend predictions. One common complaint from all the case studies was that shaping limitation prevented the technicians from being able to achieve curved shapes restricting armhole shaping for set in sleeves. These examples illustrate that the designers were specifying garment shape that replicate fully fashioned styles and methods using shaping methods developed for flat panels, such as set in and raglan sleeves. If they initiated the process by considering how to exploit the 3D shaping opportunities that tubular construction provides and which is clearly evident from the observational analysis, it is more likely that they will achieve the fit and silhouette they desire. Parachute shaping for instance was only evident on necklines and had not been used anywhere else on a garment, yet it would seem to be well suited to create volume for puffball silhouettes. The designers appeared to have little control over how garments were developed and only worked in 2D on flat specification drawings informed by pre-established garment measurement. The analysis provides evidence that the designers did not conceptualise the garment three dimensionally and therefore were really partially designing the garment.

7.9.3 The machine builders

In addition to the data analysis clearly shows that the machine builders are currently the principle influencers of the complete garment:- culture of invention, patents, intellectual property development is considered to be an investment. They are primarily considering how to develop and market the machinery.

7.9.4 The customer

7.10 The potential to innovate the knitted garment

There was evidence from all three case studies that the utilisation of complete garment technology had created innovative garments. Although all the companies were producing to very diverse target markets they had all found that complete garment technology was particularly suited to the production of dresses and skirts and as a result the range of styles that each company produced had increased. KM2 and KM3 who were not subject to the influence of high street fast fashion demands had also successfully experimented with further style diversity. Garment shaping had developed, KM1 were less experimental than KM3 but the data analysis revealed that KM2 had produced the most innovative garment shaping. They were also the only case study company where garments were evidently being produced with a 3D structure. Shaping techniques to create these structures can perhaps be described as somewhat clumsy and clearly indicative of the translation of methods used to shape fully fashioned panels. In addition to the utilisation of narrowing and widening, all the companies also exploited the capability of the machinery to knit a combination of knit structures. Most commonly this was to combine a plain knit structure with bands of knitted rib to narrow the garment at strategic regions, such as the waist. Another commonality between all the case study companies was the development of a library of garment templates. Although there was evidence to demonstrate a progression of garment design, none of the case study companies appeared to be taking as a primary consideration the notion of producing garments that exploit fabric properties to fit and flatter the female body. The comparative analysis also revealed that utilisation of complete garment technology restricted the degree of acuteness to which angles could be shaped.

The data analysis provided evidence to suggest that the utilisation of complete garment technology does provide a more flexible approach to manufacturing as the whole operation is completed on one machine. Each of the case study companies had introduced some form of product diversification. KM1, who tended to develop concepts that had been initiated externally demonstrated the most diverse product range spanning four different market sectors including fashion, technical, medical and sports. The interviewees from KM1 all acknowledged that there was considerable potential to exploit new market sectors, however a lack of investment meant that it was not possible to conduct the research and development needed to do so. KM2 were experimenting with new lines such as children’s wear and the use of luxury fibres, a strategy which had tentatively been judged as successful. KM3 were testing a limited customisation service which was more of a strategy to encourage customer loyalty than to increase sales. It does however demonstrate that the technology does provide opportunities to operate very flexibly and as a result create a more diverse and individual range of products.

7.11 Anthropometric data application

The analysis also revealed that appropriate anthropometric data was not available to those developing the garments and the data that was available tended to be inconsistent and incomplete. This was acknowledged to be an unsatisfactory situation by all the technicians. No comment was drawn at KM3. In regards to KM1 who were using data supplied by their retailers, there was particular criticism in relation to the inappropriateness of the tolerances and the data inconsistencies that were very apparent between the demands of each of their retail customers. In relation to grading it was also apparent that this was not based on the application of anthropometric data appropriate for the target consumer which did not appear to be available to those responsible. Historical data and methods were used to inform practices. KM2 had changed their grading increments because they claimed complete garments had the capacity to fit a greater variety of body sizes. The sizing systems used by each case study company were all disparate, using different grading increments and size coding systems.

The lack of precision was also evident within all the case study companies fit practices where factory workers with inconsistent body shapes and sizes were used as fit models. It was apparent that the unstable structure of a knitted garment makes it very difficult to be precise when stipulating garment dimension. In addition the processes used to determine garment dimension must consider a number of variables that can cause dimensional changes to occur such as washing, pressing and hanging. These factors all contribute to an acknowledgement that it is actually very difficult to control and predict the dimensions of new samples. This creates an acceptance that a number of fit trials will inevitably be conducted before satisfaction is gained.

7.12 Pressing the complete garment

The data analysis shows that pressing knitted garments is influential on the finished garment dimensions and considered integral to the product development process. This issue was emphasized most strongly at KM3 where they produce cashmere knitwear and the pressing process was claimed to increase the soft handle of the fibre. KM1 garments are yarn dyed and therefore are less susceptible to dimensional change caused by the washing and dyeing processes. KM2 and KM3 both used boarding or framing systems where garment dimension was measured and set during the pressing process. The data analysis very clearly indicates that using these traditional systems of pressing was inappropriate for many of the diverse range of complete garments and there was clear evidence to show that this technique had actually damaged the 3D structure of a garment at KM2. The data analysis also indicates however that none of the case study companies had found a method that was a workable alternative.

Chapter 8 Analysis of the focus groups

8.1 Introduction

Previous studies aiming to gain insight into consumer clothing fit preferences have tended to favour the administration of a questionnaire (Section 2.8.3). The exploration of consumer fit preferences that relate specifically to knitwear is a new field of study and therefore requires an experimental approach. To develop a theoretical framework for preferences of UK female consumers relating to size, fit and shaping of knitwear, four focus groups were conducted over a period of six weeks, two of which (focus group 1 & 2) were during a period of particularly warm weather which may have influenced the participants responses. An initial pilot study informed a number of methodological changes (Section 4.6.7) and procedures. The initial stages of the focus group proceedings explored consumer awareness of knit manufacture and terminology. This was considered crucial to establish methods of effective communication and data analysis. A comparative evaluation between preferences relating to woven and knitted garments ensued. Sizing issues relating to knitwear were explored and the participants were then then shown examples of complete garments and responses relating to the perceived benefits were solicited. Finally a series of questions to gauge the participants' perceptions of knitwear fit relating to their own bodies were introduced.

8.1.1 Focus group participants

Table 8.1 summarises the key attributes of the focus group participants. The proposed number of participants for each focus group was six, however although six women were invited to each, only five participants attended focus groups two and three.

Table 8.1 Focus group one: participant demographics

Focus group	Participant	Age	Self-identified body shape	Self-disclosed size	Occupation
1	**P1**	46-50	Top hourglass bust 92	8	Community nurse
1	**P2**	46-50	Rectangle vii bust 102	Bottom 12 top 14	Art tutor
1	**P3**	51-55	Top hourglass bust 92	8	Unemployed
1	**P4**	40-45	Rectangle vii bust 92	8	Nurse
1	**P5**	40-45	Triangle 102 bust	14	Occupational therapist
1	**P6**	40-45	Triangle 102 bust	12	Language teacher
2	**P7**	40-45	Spoon 102 bust 18	16	Health promoter NHS
2	**P8**	51-55	Inverted triangle 102 bust 18	14	Local authority manager
2	**P9**	40-45	Rectangle vii larger than 102 bust 16	16	Property developer
2	**P10**	46-50	Spoon 102 bust 16	18	Accountant
2	**P11**	51-55	Spoon 102 bust 16	16	Primary school teacher
3	**P12**	46-50	Top hourglass bust 92	12	Secondary teacher
3	**P13**	51-55	Top hourglass bust 102	14	Shop proprietor
3	**P14**	40-45	Top hourglass bust 92	12	Youth support worker
3	**P15**	40-45	Spoon	10	Masseur and Animater
3	**P16**	40-45	Hourglass 92 bust	12	Social work management
4	**P17**	40-45	rectangle vii and viii bust 102	14	Midwife
4	**P18**	51-55	rectangle viii 102 bust	14	Shop assistant
4	**P19**	40-45	Hourglass 102 bust	16	School art technician
4	**P20**	51-55	Rectangle viii bust 102	14	Youth support worker
4	**P21**	40-45	Rectangle viii bust 102	18	Insurance broker
4	**P22**	46-50	Rectangle viii bust 102	18	Lecturer (FE)

Refer to 1.1.1.1Appendix I.1 (p321) for the images of body shape classification.

8.2 Assessment of consumer awareness

The focus group explored female consumers' understanding and knowledge of: a) The terminology used in relation to knitted garments and b) The difference between knitted and woven garments. Initial analysis of a pilot study indicated that the participants were not always able to distinguish between knitted and woven garments. The focus group proceeding were designed to explore this finding further

Visual prompts were employed in the form of a variety of swatches, both knitted and woven (1.1.1.1Appendix I.3 p323) The participants' ability to describe and differentiate between the various swatches was explored (Q 3 - 7 1.1.1.1Appendix I p319). Focus groups aim to encourage participant interaction. The identification process was therefore shared and once one person had suggested an answer to the question others were prompted to respond. The process of analysis therefore takes this into account and uses codes to categorise the responses, taking note of temporal factors, for example, how many participants immediately made an identification of the various fabric swatches and how many had identified the swatches only after they had listened to discussion. Other factors which were coded were hesitancy or uncertainty, unwillingness to contribute and incorrect predictions. The results were summarised and presented in Table 8.2, Table 8.3 and Table 8.4. The results from all three tables were then collated and compared (Table 8.5). Drawing on these results it is possible to see the degree to which the participants demonstrated the ability to distinguish knitted and woven fabrics and understand and use specific terminology.

Table 8.2 Identification of swatch A (plain knit)

Coding categories in relation to the ability to identify and name plain knit	Participant(s)	Total No. of participants
Identified and named structure immediately	P7	1
Identified knit immediately	P1,P2, P6, P15	4
Identified as knit after discussion	P8, P10, P11, P16, P18, P12	6
Uncertain but agreed that it was knitted	P14	1
Uncertain	P13	1
Unable to identify	P9, P17	2
Incorrect identification	P4	1
No participation	P3, P5, P19, P20, P21, P22	6

Swatch A was plain knit, fine gauge, black wool. The knitted structure of the fabric was not easily detectable (1.1.1.1Appendix I.3 p323). Table 8.2 shows that one participant made an incorrect identification, suggesting that the swatch was woven, two said they could not say if it was knitted or woven and two participants were hesitant when making the identification. Only four participants provided confident and correct responses. These results provide some indication that consumers may have very little knowledge about the garments available to them.

Table 8.3 Identification of swatch B (rib knit)

Coding categories in relation to the ability to identify and name rib knit	Participant(s)	Total No. of participants
Identified and named structure immediately	P3, P7, P8, P10, P11, P18, P22	7
Identified knit immediately	P1, P2	2
Identified rib after discussion	P14, P15	2
Recognised rib after discussion	P5	1
Unable to identify	P9, P17	2
No participation	P4, P6, P12, P13, P16, P19, P20, P21 P4	9

Swatch B was a rib knit of a heavier gauge than the plain swatch and its looped structure was plainly visible (1.1.1.1Appendix I.3 p323). However there were still some participants who could not identify this swatch as a knit (Table 8.3) More of the participants did however make a correct identification of the rib swatch and seven of them used the correct terminology.

Table 8.4 Identification of swatch C (woven)

Coding categories in relation to the ability to identify and name plain knit	Participant(s)	Total No. of participants
Identified and named woven immediately	P2, P3, P18	3
Identified woven after discussion	P7, P10, P14	3
Uncertain	P13	1
Identified the fibre content only	P16	1
Incorrect identification	P15	1
Could not identify as woven	P17	1
No comment made	P1, P4, P5, P6, P8, P9, P11, P12, P19, P20, P21,	12

Swatch C was a woven linen mix and the woven structure was fairly easy to detect observationally. Only two participants were completely unable to identify swatch C as woven (Table 8.4). One of whom exclaimed that it would never occur to her to consider the manufacturing details of garments. A high number of participants did not make a comment about the woven swatch, perhaps because it was the last one to be shown.

Table 8.5 Summary of findings: respondants' knitwear related knowledge

Knowledge demonstrated	Total no. of participants
Demonstrated ability to identify all three of the fabric swatches	4
Demonstrated ability to identify two of the fabric swatches	5
Demonstrated ability to identify one of the fabric swatches	4
Demonstrated a clear inability to distinguish between fabric swatches	5
Made no comment at all	4

(Table 8.5) summarises the identification process and shows that although the majority of the participants did make at least one correct identification, five demonstrated a clear inability to distinguish between knitted and woven fabric and four of the participants made no comment at all. There are consumers within this demographic that appear to be alienated from the garment production process. Knit specific terminology such as those used to distinguish knit were not generally used by the participants, although more were familiar with and used the term for rib than for the plain knit. Although not directly solicited, the discussions revealed that a minority of the participants had hand knitting skills and were therefore more familiar with specific knit terminology.

8.2.1 Pre-conceptions

The focus group findings revealed that a number of participants were completely unable to distinguish between knitted and woven fabrics (Section 8.2) and others were uncertain or unwilling to respond. In addition to this, the data revealed that some of the participants had very fixed pre-conceptions regarding the term knitwear, which influenced their initial responses. A number of participants explained that knitwear as a word, automatically suggested thick, heavy garments which were clearly perceived as unflattering. The following quotes sum up this attitude.

‘When I think of knitwear, I think of woolly jumpers and I don't do woolly jumpers, no because they don't do anything for my shape at all so I don't do woolly jumpers…………If someone says knitted to me I think of something that my Mum might have knitted or my Grandmother, chunky, that's what I think’ (P13 Focus group transcript 3 pages 3 & 5)

‘I’ve probably got the wrong idea about knitwear because I instantly think of thick, chunky and because of my size I just think, oh I’m just adding an extra thick layer’ (P11 Focus group transcript 2 p5)

The first comment (P13) reveals the term knitwear appeared to relate to the notion of unflattering, chunky garments, but they were also perceived to be the territory of past generations, mothers and grandmothers. This theme emerged several times during each focus group. Another pre-conception was that certain fibres were specifically associated with either knitted or woven garments. This influenced the language used to describe the swatches as the following comments demonstrate:

‘So would woven be like cotton?’…….. [implying that if a fabric is woven it is likely to be made from cotton fibre] (P2 Focus group transcript 1 p8)

‘I'm not sure…….[The participant is describing a garment and is uncertain whether it is knitted or woven]…. it feels a bit knitted, but it's nylon’ [Implying that if it is nylon it will not be knitted]. (P15 Focus group 3 transcript p1)

Common terms used to describe knitted garments add to the confusion as they are often technically incorrect. The term ‘woolly’, for instance, was frequently used to denote a knitted garment, whether it is constructed from wool fibre or not. Garment names such as cardigan and jumper were also clearly understood to imply knitted garments. Many of the participants appeared to be alienated from the processes used to manufacture knitted garments. It was therefore justifiable to provide opportunities to inform, explain, illustrate and advise those participating in the focus group study. In relation to the promotion of complete garments to female consumers, this lack of consumer knowledge is likely to constrain effective communication of the potential benefits that arise from complete garment manufacture. Further investigation into specific aspects of female consumer preferences in relation to knitwear followed.

8.3 Predicted fit preference

The participants were asked to suggest how each fabric swatch would influence garment fit (Q6, focus group schedule, 1.1.1.1Appendix I p319). This question elicited some indication of the different expectations consumers have relating to woven and knitted fabrics (plain and rib knit structures)

In all the focus groups the plain knitted swatches were described as stretchy, elastic and clingy. It was generally recognised that this extensibility creates a moulded type of fit which was perceived as an advantage with comfort and drape both being identified as positive characteristics. However a disadvantage was that the moulding aspect of a knitted fabric drew attention to the participants' body regions that caused dissatisfaction.

In relation to fit preferences, a number of the participants in all the focus groups had a particularly vehement reaction to the knitted rib swatch which was described as 'chunky', 'unflattering' 'Frumpy' and 'lacking any sex appeal' . It was also claimed to be particularly unflattering for larger women with its tendency to mould to the body (FG4). One comment (FG1) suggested that knitted rib has a tendency to accentuate the lower body, creating a pear shape even on women who are not actually pear shaped [The term pear shape was unsolicited at this point and used to describe an undesirable body shape]. Another Three participants in focus group three stated that they would not wear a knitted rib garment, particularly on their lower body. The participants in focus group four concurred with this opinion. They did however suggest that a finer knitted rib and a loose fitting garment would be acceptable. The rib swatch was also said to be reminiscent of a 1970s 'shapeless' polo-neck top (FG4) which was clearly considered undesirable. The lined pattern of the knit structure itself was both criticised for emphasising the body (FG2) and praised as the vertical lines were thought to flatter the body (FG1). Some also like the idea of wearing a heavier gauge knit as a body concealer (FG2) and would choose a rib like the swatch provided, over a fine gauge plain knit.

Discussion in three of the focus groups acknowledged that garments made from a woven fabric like the swatch provided would have to be cut and shaped to create good fit. Comments also reflected fit preferences, woven garments which are less prone to mould to the body and therefore able to disguise and flatter the body were said by some participants to be preferable.

8.4 Garment characteristics: the provision of satisfaction

The opening focus group question asked participants to describe a garment they had recently purchased that made them feel good. This request made no distinction between woven or knitted garments. Question two was specific and asked the participants to describe a knitted garment they had recently purchased that made them feel good (Q1 & Q2 Focus group schedule 1.1.1.1Appendix I p319). The aim of these questions was to allow the participants to introduce themselves, tune into the topic and focus on positive feelings to help them relax. The analysis of this descriptive data generated a number of interesting findings. The initial stage of coding identified the type of garment that each participant had identified. In response to Q1, Five participants described garments that were made from knitted fabric and ten described woven garments. The other seven descriptions did not include enough detail to determine whether they were knitted or woven. There was a marked difference between the garment choice from question two, when only two participants described a knitted dress and question one, when 11 described dresses (Table 8.6). The responses suggest that there may be a relationship between a woven dress as a garment of choice and feelings of well-being. This relationship was weak when the participants focussed specifically on knitwear when knitted tops become a priority.

Table 8.6 Participants garment selection (garments that make you feel good)

Type of garment described (Q1)	Described by: (No of participants)	Type of knitted garment described (Q2)	Described by (No. of participants)
Dress	11	**Cardigan**	10
Top	3	**Top**	5
Cardigan	3	**Jumper**	2
Jacket	2	**Sweater**	1
Waistcoat	1	**T shirt**	1
T shirt	1	**Dress**	2

During the analysis it became evident that certain garment characteristics were repeatedly identified by the participants within the garment descriptions, these characteristics formed the initial coding categories. It was also possible to determine specific consequences relating to these coding categories, namely garment purchase, satisfaction and dissatisfaction. These formed three secondary coding categories. Table 8.7 lists all the initial codes relating to garment characteristics and provides definitions for each code.

Table 8.7 Coding definition: garment characteristics

Garment characteristic	Definition of garment characteristic
Colour	Either the whole garment colour(s) or a portion of the garment colour(s)
Fit	The relationship between the garment and the body
Silhouette	The shape of the garment in relation to the body
Styling details	Garment details, determined by style choices made during the product development process
Size coding	the code that communicates the garment dimensions to the consumer
Fabric	The material from which the garment is constructed
Comfort	A physical or an emotional sense of ease and satisfaction.
Chunky/Fine (gauge)	The weight or thickness of a knitted garment
Knit structure	The knit structure such as rib or plain relating to the configuration of the knitted loop
Garment care	Requirements regarding the way a garment is laundered and maintained

Table 8.8 relates to the analysis of descriptions of the non-specific garment (Q1) and Table 8.9 to the analysis of the knitted garment descriptions (Q2). They list each time a particular coding category was found in the data. A comparison of the tabulated data reveals that the most striking difference was that comfort featured many more times in the knitwear descriptions. The types of characteristics mentioned change slightly, with some knitwear specific concerns emerging, namely the weight or thickness of the garment and garment care. The analysis also looked at the relationship between the primary and secondary coding categories, namely which characteristics have been identified as most influential in motivating purchase and providing satisfaction or dissatisfaction. The notable difference is that although five identified fit as being the cause of purchase when describing a non-specific garment, none of the participants identified fit as the cause of purchase within their knitted garment description. There were also a small number of knitted garment characteristics included that had cause dissatisfaction.

Table 8.8 Coding summary: importance of garment characteristics (Q1)

Garment characteristic	Primary motivator to purchase (No. of participants)	Satisfied with characteristic (No. of participants)	Dissatisfied with characteristic (no of Participants	Included this characteristic (No. of participants)	Total (No. of participants)

colour	5	3	0	6	14
fit	6	5	2	0	13
Silhouette	0	2	0	5	7
Styling detail	0	1	0	8	9
Fabric	0	2	0	7	9
Comfort	0	1	0	0	1
Size code	0	1	0	0	1

Table 8.9 Coding summary: importance of knitted garment characteristic (Q1)

Garment characteristic	Primary motivator to purchase (No. of Participants)	Satisfied with characteristic (No. of participants)	Dissatisfied with characteristic (no of Participants	Included this characteristic (No. of participants)	Total (No. of participant s)
colour	2	0	0	11	13
Styling detail	0	4	0	5	9
fit	0	4	0	4	8
Comfort	1	2	1	4	8
Chunky/fine (Gauge)	0	0	3	4	7
Silhouette	0	0	3	3	6
Knit structure	0	0	1	2	1
Garment care	0	1	1	0	2

The following analysis focusses on each of the identified coded garment characteristics individually. The data generated from the participants garment descriptions also introduces a number of key and sub themes (Table 8.10) relating to factors that influenced the participants' preferences.

Table 8.10 Secondary identified from garment description data

Secondary codes identified	Factors that influence fit preferences
1	**Body Image**
2	**Body size**
3	**Body shape**
4	**Femininity**

8.4.1 Fit

During the first set of descriptions, fit can be identified as a key concern for the participants and many of the comments reflected attitudes to body image. Three participants described woven garments that concealed body regions which were identified as causing dissatisfaction. Two participants acknowledged that although there was some dissatisfaction with one aspect of the fit (both instances concerned the fact that the garment revealed the participants' bras), they still derived feelings of well-being from these garments. This is indicative that women not only buy garments that do not completely satisfy their fit demands but that garments judged to be unsatisfactory in some aspects, can still produce positive feelings for the wearer. The ability of a garment to provide general satisfaction may therefore not be entirely reliant on fit satisfaction.

The descriptions of knitwear appear to register less concern in regards to fit, than was evident from the responses from question one. No one claimed that the fit had prompted them to purchase a garment. There were some comments that indicated preferences to knitted garments that concealed certain regions of the body, indicative that knitted garments were used to disguise body regions. This concurs with some of the responses to question one where a relationship between fit preferences and body image was clearly identified. One participant's comment indicated a preference to the way the knitted garment moulded to the body around the shoulder, bust and upper arm body regions [describing this type of fit as 'slimming'] and then draped over the abdomen, buttocks and hips to conceal these body regions. This description was of a garment that was being worn at the focus group. Other participants were therefore able to comment and all agreed that although it was preferable not to accentuate the abdomen, hips and buttocks, a moulded fit around the upper body emphasised the wearer's feminine shape, which was flattering. Only knitted garments can fit the body in this way and there was therefore early indication of a specific relationship between fit preferences and knitted garments. This comment came from a group who were size 14 and under (The wearer was a size 14).

8.4.2 Colour

Colour was the characteristic most often mentioned by the participants when describing both their garments and it was identified to be a cause of satisfaction and a motivator to purchase by a number of participants. None of these comments however reflected a relationship between colour and the self. No one for instance suggested that a colour was selected because it suited them or flattered their body shape. Likewise none of the participants acknowledged that the colour was selected for fashion reasons. This open question did not therefore draw out a perceivable relationship between colour and fashion or colour and the body.

8.4.3 Silhouette

The garment characteristic silhouette is closely related to fit and can perhaps be classified as a sub-category of fit. Terms used by the participants to describe the garment silhouette such as: ‘fitted’ [to the body] and ‘floaty’ [floating around the body] implicitly refer to the relationship between the garment and the body. The description provided by two participants: ‘fitted across the bust and loose over the hips’ and ‘fitted but not tight, goes in at the waist ‘explicitly described the shape of the garment in relationship to the body. Two participants used fashion industry terminology; shift shape, and empire line to describe the shape of their garment. Both of these shapes, it was emphasised, flattered the participants’ body shapes. All these comments are indicative that women are very aware of their bodies when considering garments within the context of the provision of satisfaction. The ability of a garment to provide feelings of satisfaction is likely therefore to be conditional on the relationship between the garment shape and the wearer’s body. In relation to garment silhouette the descriptions from the knitted garments did not significantly differ with those from the descriptions of the non-specific garments.

8.4.4 Comfort

During the descriptions of the non-specific garments comfort was only mentioned by one participant. This related to its perceived ability to maintain a cool body temperature during a period of hot weather. It is of note that only one participant included comfort in the garment description as the question directly asked participants to consider garments that made them *feel* good. The responses appear to show that the overwhelming majority related feeling good to other factors, particularly related to feeling good about their body image, over and above comfort. In contrast, comfort related factors featured as a high priority in many of the descriptions about knitwear and insulation properties, was also a primary comfort concern. There were also a number of adjectives used, such as ‘Cuddly’, ‘soft’ ‘woolly’ and ‘fluffy’ that reflect an acknowledgement of tactile or sensorial comfort. At this stage in the proceedings none of the participants referred to the relationship between the extensibility of a knitted garments and the potential for a more comfortable fit.

8.4.5 Styling detail

Examples of styling details that were described by the participants in response to the first question were, neckline and collar shapes, ruched and ruffle details and embellishments such as bows. A number of participants linked a styling detail to satisfaction, V shaped neckline was for instance described as flattering. Buttons, sleeve length and the inclusion of a collar were also causes of satisfaction. Participants did consider style details in reference to their bodies with comments about garment length and sleeve length.

8.4.6 Fabric

The descriptions from the non-specific garments show that some of the participants were concerned with the fabric. Specific fibres, such as silk were identified as a source of satisfaction. Fabric properties that influence the drape and structure of the garment were also implicit within some of the comments and two participants related these properties directly to the relationship the garment had with the body. Jersey was identified as being ‘soft and flattering’ and a ‘Strong, thick cotton’ was identified as being particularly satisfactory because it provided a stable structure that could shape the body. This quality tends to be specific to woven fabrics. There was also some indication that the participants were making a distinction between knitted and woven fabrics, two using the term ‘jersey’ and one hesitantly suggested her garment ‘felt’ knitted.

8.4.7 Weight (gauge)

This knit specific garment characteristic was added because a number of the participants described their garments as ‘fine’ ‘chunky’ or ‘not chunky’. There was a notable amount of concern displayed about this issue, with three participants, from the over size 14 groups, emphasising that they would only wear ‘fine’ knitted garments. Another comment suggests that there is an automatic association between knitted garments and ‘thick’ or heavy weight garments. There appears to be a relationship between the female consumer’s pre-conceived expectations in relation to the bulkiness of a knitted fabric and its impact on fit. Responses indicate that heavy weight knitwear is associated with an increase in body size resulting in dissatisfaction. This concern regarding fabric bulk or weight appears to be particular to knitwear.

8.4.8 Knit structure

This characteristic is obviously knit specific and was only mentioned by three participants, one of which provided the correct terminology when referring to a rib. There was some indication that there is a relationship between knit structures and knitwear fit preferences. One participant described the ‘stripes’ [She is referring to a knitted rib] as being flattering on the body. Another participant stressed that her garment was not a rib, implying that a ribbed garment would not be a preference. The only other comment does not attribute the knit structure [cables described as ‘the style of arran jumpers’] to being a source of satisfaction. However the inclusion of this cable knit structure in the description implies that it does contribute to the overall sense of satisfaction.

8.4.9 Size coding

Only one participant mentioned the size code in her garment description. It is however worth noting because the experience of finding a garment that fitted, but that was coded as a size smaller than this participant typically wore, induced considerable feelings of satisfaction. This anecdote demonstrated that vanity sizing, often blamed as one of the causes of sizing inconsistency within the market place, can result in feelings of satisfaction for the consumer. These positive feelings can remain unchanged, even when the consumer is aware that the size code in question is merely a consequence of vanity sizing.

8.4.10 Garment Care

Concern with garment care was an issue that emerged only in the knitwear descriptions. One participant very strongly asserted that she did not tend to buy knitwear because it had to be hand washed and dried flat and therefore struggled to think of a garment to describe. The only other comment about garment care and its impact on satisfaction was that the garment described had washed very well. These comments are worth noting as they do indicate that consumers’ negative experiences can have a long-term impact on preferences and buying habits.

8.4.11 Other issues

In addition to the garment characteristics listed above, other comments from participants suggest that garments can represent or embody an expression of personality. The use of adjectives such as funky, risqué, quirky, old timey, punky, wild and eccentric, to describe the garment reveals a relationship between garment satisfaction and the desire to project certain personality traits. This can also be viewed within the context of identity and the relationship between garments and the construction of identity. The use of these terms supports the idea that women use garments to indicate peer affiliations and assert certain lifestyle choices. Although fashion was only mentioned by two participants, these descriptive terms could also well reflect the influence of fashion. Other concerns that arose were age related, occasion related and one participant stated she only ever bought garments for functional reasons.

More knit specific issues emerged, two participants stated the age of their knitted garments, acknowledging with satisfaction, that they had remained in good condition over a long period of time. Another participant also claimed that her garment, although highly valued, was old and nearly worn out. This reference to longevity may be particularly relevant to knitwear, bought for reasons other than fashion and therefore less susceptible to in-built redundancy specific to fashion garments. 1.1.1.1Appendix J p330 summarises the responses from the opening question. 1.1.1.1Appendix J.1 p331 summarises the results from question two.

8.5 Garment purchase: Influencing factors

To gain further understanding of consumers' fit preferences in relation to knitwear and how these might differ from woven garments preferences, a second exploration was conducted. The participants were provided with ten possible choices in the form of prompt cards representing a pre-identified set of garment characteristics. These garment characteristics that may influence the decision to purchase had emerged from the analysis of the data from the pilot focus group. They included fit, colour, comfort, fashion, body shape improver, sex appeal, drape, status, warmth and age appropriate. The participants were asked to make a group decision about which of the ten characteristics they would prioritise when selecting: firstly a woven garment and secondly a knitted garment, for purchase. The ranking of factors are presented in Table 8.11 (woven garments) and

Table 8.12 (knitted garments). Each factor has been given a numerical score, with 1 being the most influential and 5 being the least influential. The participants were allowed to rank factors together, for example if the group decided they ranked fit, comfort and colour equally they were all given the same score. The data from the group decision making process has been analysed using the ten influencing factors as the key coding categories. It was therefore possible to comment on why certain factors were considered more influential and whether some participants played a more active role than others. In addition and in view of the potential for communication problems (Section 8.2.1) the analysis also documents instances of mis-understandings.

Table 8.11 Factors that influence the purchase of woven garments

	Focus group 1	Focus group 2	Focus group 3	Focus group 4
Influential value 1 (most)	Fit, Colour, Comfort Fashion	Fit	Fit Body shape improver	Fit
Influential value 2	Body shape improver Sex appeal Age appropriate	Age Appropriate Body shape improver	Colour	Sex appeal Body shape improver
Influential value 3	Warmth	Sex appeal Colour fashion	Comfort Drape	Drape Comfort Colour
Influential value 4	Drape	Status Drape Comfort	Warmth	Fashion Warmth
Influential value 5 (Least)	Status	Warmth	Fashion Age appropriate Status Sex appeal	Age Appropriate Status

Table 8.12 Factors that influence the purchase of knitwear

	Focus group 1	Focus group 2	Focus group 3	Focus group 4
Influential value 1 (most)	Fit Colour Fashion Warmth Age appropriate Comfort	Fit Body shape improver Colour	Fit Body shape improver	Fit Body shape improver Warmth
Influential value 2	Body shape improver	Comfort Drape	Drape	Drape Colour Comfort
Influential value 3	Drape	Warmth Fashion	Age appropriate Colour	Sex appeal Fashion
Influential value 4	Sex appeal	Age appropriate	Warmth Comfort Sex appeal	Age Appropriate
Influential value 5 (Least)	Status	Status Sex appeal	Fashion Status	Status

Table 8.13 shows the combined results from all the focus groups and the total score for each factor. In contrast to the findings from the garment descriptions, where fit appeared to be less of a concern for knitwear, when asked directly about fit, it was rated as the most important factor of preference for both knitwear and woven garments. Body shape improver, referring to a very particular type of fit, also rated

very highly for both garment categories. Colour comes only slightly lower down on the ranking, concurring with the data analysis of Q1 & Q2 (Section 8.4 p196). Comfort also features moderately high for both categories of garment. The garment descriptions (1.1.1.1Appendix J p330 &1.1.1.1Appendix J.1 p331) appeared to indicate that knitted garments were more able to provide satisfaction through comfort than fit. However when asked directly in relation to the degree to which a knitted garment is assessed before purchasing, fit was rated as the highest priority. Comfort was rated as a slightly less important factor for knitted garments than for woven garments, which contradicts the previous findings (Section 8.4). This result was however influenced by the fact that warmth was rated as a separate factor and was in fact perceived to be considerably more important for knitwear than woven garments. In terms of comfort, the insulating properties of knitwear therefore appear to be well recognised whereas the ability to provide a less restrictive, more comfortable fit is perhaps less explicitly recognised.

The ability to signify status when wearing either woven or knitted garments was considered to be unimportant by all the groups, although the results from the discussion highlight some exceptions to this (Section 8.5.10). Sex appeal scores higher in relation to woven garments and drape has a slightly higher score when related to knitted garments.

Table 8.13 Ranking the influencing factors for knitted and woven garments

Order of Ranking	Woven garments	Knitted garments
1	Fit (4)	Fit (4)
2	Body shape improver (7)	Body shape improver (5)
3	Colour (9)	Colour (7)
4	Comfort (11)	Comfort (9) Warmth (9) Drape (9)
5	Sex appeal (12)	
6	Drape (13) Fashion (13)	
7		Age appropriate (12) Fashion (12)
8	Age appropriate (14)	
9	Warmth (16)	Sex appeal (16)
10	Status (19)	Status (20)

The following sections report on the findings from the discussion that accompanied the selection process when placing the prompts in order of importance. Each section relates to a different factor of influence.

8.5.1 Factors that influence garment purchase: Fit

The participants from all four focus groups were quick and decisive when placing fit as a priority when purchasing both knitted and woven garments. The general group agreement limited the level of discussion about fit. There was however some debate that helped to clarify the participants' understanding of the term fit. On two occasions the word fit was interpreted to mean a close fitting garment, which caused at least one participant to place fit as an influencer to purchase very low down in the ranking order. However on both occasions the discussion resolved the misconception and acknowledged a more general interpretation of the term fit. Fit satisfaction, it was agreed, relies on personal preference, no matter how loose or tight the garment is. It is this type of discussion that justifies the use of focus groups for data collection, enabling a thorough analysis of how language is used and interpreted and providing opportunities for discourse and explanation.

Participants in focus groups one and two agreed that comfort was an integral aspect of fit, particularly for woven garments as bad fit can inhibit movement. Body shape improvement was also suggested to be relative to fit. In focus group two, the participants discussed sacrificing comfort for the sake of improving body shape. No one said they would choose uncomfortable clothing for the sake of improved body shape, however three admitted to wearing garments (two woven jackets and one knitted cardigan) that do not fasten at the front because they looked good. One participant stated she wore trousers that were far too big because they were comfortable. This habit however was exclusive to work which she considered to be an environment that did not warrant too much consideration regarding dress. These anecdotes illustrate how garment fit preference is a personal choice and can be influenced by a variety of differing factors, such as occasion, aesthetics and fabric.

The participants from all groups did not discuss fit specifically in relation to knitted garments apart from to say it was of primary importance.

8.5.2 Factors that influence garment purchase: Body Shape Improver

Body shape improvement was ranked as a high priority when purchasing both a woven and a knitted garment. Woven fabric properties and their perceived ability to constrict and sculpt the body was regarded as positive in regards to body shape improvement, as this following comment about jeans demonstrates

‘They squeeze everything in, like a corset effect’ [P15, discussing jeans, Focus group 3 transcript p48]

In contrast, the discussions about knitwear tended to introduce reasons why body shape would not be improved. The pre-conception that knitwear is inherently thick and bulky (Section 8.2.1), influenced the debates about the relationship between knitwear and body shape improvement. Terms such as ‘boxy’ and ‘chunky’ were once again used to describe ‘unflattering’ knitted garments. The following quote demonstrates a typical attitude

‘Well it wouldn't improve my shape wearing a knitted jumper’ [P18 Focus group transcript 4 p40]

There were indications that body shape improvement was more of a priority for the participants who had self-disclosed as over a size 14. They agreed that if a knitted garment did not improve their body shape, they would not wear it, even if it had all the other desirable qualities, namely warmth, comfort, drape, fit [Focus group transcript 4 p39]. The following quote from a self dis-closed size 8 participant who perceived her stature to be an issue illustrates that women prioritise flattering fit over comfort. In this case it is the participant’s perception of non-conformity to the norm (shorter than average) that influences the fit preference.

‘A big baggy thing on me would look really ridiculous because I’m so small, if I had a big baggy jumper on which I think would look lovely and comfy, my legs would look this big [indicates a short distance, this provokes Laughter] So even camping I’d have to get one that wasn’t as long’ (P6 focus group transcript 1 p27)

Some of the other participants who had self-disclosed as under size 14, indicated that knitwear specifically purchased for its ability to insulate and create comfort is not expected to be flattering and can therefore still provide satisfaction. The data indicates that in terms of fit preference, woven garments score higher than knitted if consumers are seeking to improve their body shape. Further investigation is however needed before firm conclusions can be drawn.

8.5.3 Factors that influence garment purchase: Colour

Although it was generally agreed that colour was a high priority when selecting both knitted and woven garments the data did not reveal any depth of information around how it influences. Only one focus group discussion made any comparison about colour in relation to knitted and woven garments, when it was agreed that it was easier to wear knitted garments in bright colours than woven garments. The majority of the discussion about colour was in abstract terms, only one participant related colour to body image, stating she was aware of which colours suited her and gave these priority when purchasing garments.

8.5.4 Factors that influence garment purchase: Comfort

Comfort was generally acknowledged to be a high ranking factor of influence when purchasing both knitted and woven garments. The discussions that took place during this ranking task did not reveal any obvious differences in the way comfort was regarded in relation to woven and knitted garments, perhaps because the task did not directly ask them to make comparisons. Only one comment indicated that extensible knitted garments were less restrictive than woven garments and were therefore

'harder to be uncomfortable'. [P3 focus group transcript 1 p31]

This comment perhaps sums up why so little reference is made to the influence of extensibility on the fit of knitwear, it appears to be implicitly accepted without any further consideration. The only other comments relating to knitted garments and comfort were from four participants who said that knitted polo necks caused discomfort.

When discussing comfort in relation to woven garments one discussion drew attention to the fact that at times a conscious choice between comfort and other factors which relate to aesthetics, is made. Comfort it was suggested might be sacrificed in favour of sex appeal or improving body shape [Focus group transcript 1 p32].

8.5.5 Factors that influence garment purchase: Sex Appeal

The participants ranked sex appeal as a higher priority in relation to purchasing woven garments than for knitted garments. The discussions about how sex appeal related to knitted garment purchase revealed some differences of opinion which resulted in more debate and consequently some interesting findings. Once again pre-conceived notions of knitwear influenced the discussions and introduced the idea that knitwear may generally be perceived as 'old fashioned' and therefore would never have been associated with the term 'sex appeal' as the following comments demonstrate'.

'The word knitwear does not go with sex appeal' [P12 Focus group 3 transcript p35]

'I can't think of any knit I've ever had that has sex appeal' [P6 Focus group 1 p28]

This attitude influenced the ranking for sex appeal, even though not everyone shared this view. One discussion differentiated between lighter gauge summer knitwear, which they agreed could be sexy, and heavier gauge knitwear which primarily provided warmth and comfort. Marilyn Monroe's sweaters, lightweight angora yarn and low cut cowl necks were all identified as examples of sexy knitwear [Focus group 3 transcript p84]. However even some of those who championed the notion that knitwear can be sexy admitted that sex was not the first thing that sprung to mind from the term knitwear. During the discussions relating to woven garments the comments related much more to the participants own perceptions of self. Some participants revealed a reluctance to acknowledge sex appeal at all. One stated that she did not consider sex appeal to be of any relevance to her [P8 Focus group transcript 2 p25]. Another revealed that she found it difficult to even talk about dressing in a sexual way [P16 focus group 3 transcript p36]. These discussions reflect that complex cultural issues are encompassed in consumer's preferences when selecting any type of garment. The discussion revealed a dilemma between dressing to be sexually appealing and feeling stigmatised if perceived to be dressing for the male gaze. This is demonstrated by the comment below from a participant who is arguing that sex appeal should be higher in the ranking order

'It's not like sex appeal when you're trying to attract men but just feeling good about yourself' (P 17 Focus group transcript 4 p38)

This argument influenced the group to move sex appeal up in the ranking order.

8.5.6 Factors that influence garment purchase: Drape

Drape was given a higher position in the ranking order as a priority for knitted garments. There was less discussion relating to drape but comments did show that the participants recognised two factors specific to knitted garments in relation to drape. Firstly they associate garments such as shawls and wraps with knitwear, secondly properties of knitted fabric provide good draping qualities.

8.5.7 Factors that influence garment purchase: Fashion

Fashion was not rated as a high priority for either knitted or woven garments. This generally low order of ranking is supported by the findings from the opening questions where no fashion influence was evident within the garment descriptions (Section 8.4). The discussion around fashion provoked strong reactions and opinionated responses. A number of participants appeared to want to disassociate themselves with the notion of fashion altogether [Focus group 2 transcript p33]. It was also described as something that is hard to avoid and making efforts to gain fashion awareness was thought to be unnecessary because whatever is in the shops will, by definition be fashionable [Focus group 3 transcript p39]. Comments indicate that fashion influence was blamed for reducing both the life of a garment and a women's ability to express herself as an individual. In contrast a small minority of participants perceived fashionable garments as desirable and something they actively sought.

With specific reference to knitwear, it was suggested by a number of participants that functional requirements, particularly warmth and comfort are considered more important than fashion. This need for functionality, it was claimed influenced an expectation for longevity with regards to knitwear. Consequently classic styles are often sought, rather than trend led fashion products. This expectation for longevity, accords with the findings from the opening questions when one participant chose to describe a knitted garment that was ten years old and another that was 24 years old.

The participants were generally negative about the notion of fashion as an influential force and the majority did not appear to actively seek out trend information or wish to be perceived as a fashion follower. There was however evidence that suggested many of the participants were actually following fashion. Draped knitted garments for instance, which were fashionable at the time and were being worn by the participants and featured in some discussions (Section 8.5.6). Comments also indicated that many of the participants felt a need to distinguish themselves from the older generation (Section 8.5.8), an attitude which could be indicative that fashion is an influence.

8.5.8 Factors that influence garment purchase: Age Appropriate

The participants did not rate age appropriateness to be a primary consideration when purchasing garments. In the discussion however there were a number of comments demonstrating a wariness of looking both too young 'mutton dressed as lamb' and too old 'frumpy'. One of the consequences of this was that certain retailers were avoided as it was felt that they only catered for a younger consumer. Garments that were perceived to be only appropriate for younger women appeared to relate to anything that accentuated or displayed too much of the body. The words 'tight', 'short' and 'skimpy' were used. In accordance with the view that knitwear can be 'old fashioned' (section 8.4.11) the fear of looking 'frumpy' has particular resonance and although no examples were provided, there was concurrence amongst the groups that certain types of knitwear were only suitable for older people.

8.5.9 Factors that influence garment purchase: Warmth

Warmth as a factor of influence to purchase was rated higher for knitwear than for woven garments. The discussions reflected this with most agreeing that knitted garments tended to be associated with maintaining body warmth. One discussion introduced the idea that it is currently common for people to layer garments which reduces the need for one warm garment. Other comments reflect current lifestyles where it is uncommon for people to be outside of a warm environment and consequently this reduces the need for garments that insulate against the cold. It should be noted that some of the focus groups were conducted during a hot period in the summer, which influenced the discussion and many of the participants were wearing cool, fine gauge knitted garments.

8.5.10 Factors that influence garment purchase: Status

Although all the focus groups placed status as the least important influencer when purchasing woven and knitted garments much discussion was generated by this prompt and some comments did acknowledge status to have some influence. The word status appeared to be associated with a multitude of undesirable notions, as a consequence the participants found it difficult to claim that status issues would influence their purchasing habits. Those who did acknowledge that they were careful not to dress outside of their perceived social status were apologetic of the fact and their statements equated to confessionals. Comments indicate that the word status is suggestive of social climbing, attempting to display wealth through dress, the display of heavily branded clothing or ‘power dressing’, all of which was judged as distasteful and socially unacceptable.

Other less emotive examples of status clothing provided were luxury fibres such as silk and bridal attire with embellishment such as hand beading. One participant reminisced about her childhood [P10 Focus group transcript p38] when machine knitted garments carried more status than hand knits. It was thought that this attitude was no longer applicable because hand knitting skills are currently rare and hand-made garments are highly valued.

The participants appeared to more readily accept the display of status if it was related to working roles or specific occasions, such as interviews. However this did not impact on their general agreement that status as an influence to purchase garments is not a priority.

8.6 Knitwear sizing provision

The participants were asked about sizing provision from retailers, specifically whether it was easy for them to find knitwear in their size. There were different responses, focus groups one and three (Size 14 and under) generally agreed that they had no problems finding knitwear in their size. Participants in focus groups two and four (over a size 14) stated they found it difficult to find knitwear in their size. Participants were also given prompt cards outlining four different systems of sizing codes used by UK retailers (Power and Otieno 2008). For purposes of this research 10, 12, 14, 16, 18 will be termed as double numeric; 1, 2, 3, 4 as single numeric; 36, 38, 40, 42 as European numeric and XS S, M, L, XL as descriptive. Discussion was prompted around levels of satisfaction and understanding of the various coding categories provided. Although the facilitator stressed that participants should consider knitted garments during their discussion it is likely that some of the views related more generally to clothing size codes. Responses from this series of questions were coded into the three following categories: body shape dissatisfaction, sizing inconsistency and size communication.

8.6.1 Body shape dissatisfaction

When asked about their experience of sizing provision, many of the participants' first reaction was to identify a region of their body that caused them problems when attempting to find standard sized garments. These comments related to two issues: firstly that they appeared to blame their own bodies for their failure to locate garments in sizes that fit, and secondly this inability to find sizes that fit increases feelings of being proportionally outside of the norm. In relation to issues of body image this decreases satisfaction. An extensive list of differing 'problem' body regions were mentioned including: a broad back, short stature, short body length, narrow shoulders and protruding stomachs, thighs, and buttocks. It was agreed that garments which disguise or hide these perceived body defects were desirable. Extensible, moulding knitted garments that accentuate these body regions were avoided. There was a clear association between the participants' inability to locate clothing that fitted adequately and body dissatisfaction.

8.6.2 Size code identification

When asked to identify which size code system the participants' best related to, the double numeric system (10,12,14) was the first choice of preference. Descriptive coding (S, M, L) was also identified as easy to understand and there was a suggestion that it was most often used for knitted garments. During the discussion in all the focus groups, double numeric sizes were used by the participants as the benchmark code. The other coding systems were often translated into double numeric values during the conversation: 'Is 36 a size 12?' or 'I could guess that large was a size 16' These comments provide further confirmation that double numeric size coding is the system the participants' most readily identified with. It was however evident from the discussion that the participants were very aware of a lack of standardisation in the use of double numeric size codes, a size 12 in one shop, for instance, would be a size 14 or 16 in another.

8.6.3 Size code inconsistencies

Comments made during all the focus groups revealed that the participants were not only aware of substantial inconsistencies in sizing provision on the high street but that also it was a major source of dissatisfaction. This non-standardisation was blamed for increasing the number of garments that had to be tried on when shopping which decreased their satisfaction with the shopping experience. Many of the participants said the size they bought varies depending on the retailer and some had experience of varying over a range of at least three sizes for instance sizes 10-16 [P11 Focus group transcript 2 p1, P9, P & P8 Focus group transcript 2 P47 – 48 P19 focus group transcript 4 p50]. Comments also revealed that participants were dissatisfied by what they perceived to be inconsistencies in sizing provision within individual retailers which resulted in a loss of trust. For some participants value for money appeared to be closely related to the way clothing was sized. Shops whose sizes were seen to be smaller than average were thought to be saving money by skimping on fabric. In reality this view would only be valid if larger sizes were more expensive. It was however an opinion that was voiced by two participants, both of whom were a self-disclosed size 18. This idea that retailers 'skimp' to save money implies that generous sizes are perceived to be of a higher quality. Retailers who grade their garments up, or introduce what has become known as vanity sizing are therefore likely to be regarded favourably. This practice however is known to increase sizing inconsistency on the high street.

The inconsistent use of size coding systems was clearly confusing and the participants complained that the Single numeric and European numeric coding systems were difficult to interpret. Several of the older participants thought that the European codes (33, 36, 38, 40) related to chest or bust sizes, expressed in inches. This is perhaps not surprising as knitted garments have used imperial chest measurement to indicate sizing in the past. One participant who had lived in Spain said she would interpret the European coding system differently in the UK, where she would presume it indicated bust or chest dimension. Comments about single numeric size codes (1, 2, 3, 4) showed that the participants were unsure whether retailers use 1 or 4 to indicate the smallest size. The range of sizes this system covers was also said to be unclear. It could for instance indicate a range of outsize garments or be limited to very small sizes. Another comment confused American size coding, used in Gap clothing with single numeric coding. The practice of producing garments in one size was also discussed, prompted by a one size draped knitted cardigan with no fastenings, worn by one of the participants. She suggested that she had seen a wide spectrum of women in different shapes and sizes wearing these cardigans, the participants did not however discuss the stretch properties of the knitted cardigan in relation to its capacity to fit a range of differing body sizes.

During focus group 3, the evident dissatisfaction with sizing inconsistencies initiated discussions about how sizing information could be more effectively communicated to the consumer. Most of the participants were dismissive about the idea of retailers documenting key measurements such as waist, hip or bust, on garment labels. One suggestion implied that more information would confuse consumers and deter those whose body shape did not comply with the measurements listed. This view was disputed by another participant [P15 focus group transcript 3 p58] who explained that she had forced herself to take an educated approach when purchasing jeans. She now knew the appropriate measurement information that helped her make an informed choice.

The communication of garment dimensions was suggested to be particularly important when purchasing garments online. Only two participants had experience of purchasing garments from web based sources [P18 & P19 Focus group transcript 4 p45]. They claimed that it was crucial for companies to provide clear and reliable sizing information. A number of participants said they would not use online facilities to buy clothing because they prefer to try garments on before purchase.

8.7 Vanity sizing

The final size related question asked they if they would purchase a garment that was coded as a size larger than they normally bought. (Table 8.14) summarises the results from this question and the following section reports on the discussions provoked by this question.

Table 8.14 The influence of vanity sizing

Response to question (would you purchase a garment coded a size larger than you normally buy?)	Participants who responded
Yes	P1, P3, P20,P14
Yes with reservations	P6, P17, P16, P9, P10
Maybe	P19, P15
No	P5, P22, P13, P7
No comment	P2, P4, P8, P11, P12, P18, P21

Although seven of the participants did not take part in the discussion provoked by this question, the majority did and there were a variety of viewpoints. The participants who said yes indicated that the size code on the garment was not considered to be of any importance. It was the garment itself and how it looked on the body that mattered. Some of the participants said they would still purchase the garment but four suggested they would cut the label out [P6 focus group transcript 1 p47, P9 Focus group transcript 2 p50, P16 focus group transcript 3 p55, P17 focus group transcript 4 p48] and in one case would also inform the retailer that their sizing was incorrect [P6 focus group transcript 1 p47] and another said she would have to 'give myself a talking to' [P10 Focus group transcript 2 p51] to prevent being negatively influenced by the size code. Two participants said they might still purchase the garment indicating that it does have an influence on their decision making. Those who said no were quite clear that a size code they perceived was indicating they were a larger size than they thought they were, would prevent them from buying the garment.

8.7.1 Increased satisfaction

The data analysis suggests that size codes indicating that a garment was larger than the participant perceived herself to be had negative impact on some. It was also evident from comments that the practice of vanity sizing had led to increased garment satisfaction and brand loyalty. Interestingly the anecdotes show that being aware of vanity sizing, did not appear to decrease their satisfaction.

'I can get stuff that is medium and I think ooh it's medium… [indicating that it is pleasing]… but it's clearly not medium, I just know they're generous in their cut' (P22 focus group transcript 4 p49)

‘I looked at the label and it was a size 16, but I’m not I’m an 18 to 20, but I was so thrilled it was a 16, I had to have it’, (P11 focus group transcript 2 p2)

One of the participants (a size 18 herself), who worked in the accounts department for a mail order clothing company also provided some insight into her experience of vanity sizing from within the industry.

‘I think we get far less returns when they make things a size bigger ….. people will order a size 16 when they know they’re a size 18, …… we make more money if we call a size 18 a size 16 then people who are a size 18 will buy it and not return it’ (P10 focus group transcript 2 p50)

These findings indicate that it is perhaps understandable that retailers continue to label clothing to flatter women into believing they can fit into smaller garments. Size indicators appear to have a very real psychological impact on some women and their sense of self-worth. The participants who expressed particular satisfaction with vanity sizing during the focus group research were the largest women in the sample. (self-disclosed size 18 and 20) and those who said size codes would prevent them from purchasing a garment were self-disclosed size 14, 14, 16 and 18. The data indicates that it was the larger women who were most influenced by vanity sizing.

8.7.2 Perceived relevance of size codes

In conflict with those participants who had described being flattered by vanity sizing, others claimed that the size codes on the garments were irrelevant. This attitude demonstrated an acceptance of the fact that each individual retailer’s size codes reflected an independent approach. Size codes were perceived as unreliable indicators of body size or shape and were used merely as a basic guideline or starting point. Fit judgement appears to be suspended until a garment is tried on. These consumers appear to have developed their own methods to assess fit, based on trial and error, which is almost independent of the sizing information provided by the manufacturers or retailers. The following comments illustrates this attitude

‘this favourite top is a 10, so it bears no resemblance to any other clothes that I’ve got so I know that sometimes I can get a 12 or a 16 you know. It’s irrelevant really’.

Two of the three participants who were most adamant that they were not influenced by vanity sizing were a self-disclosed size 8 and one was a self-disclosed size 12. They therefore fall at the opposite end of the size spectrum to those who admitted to be influenced by vanity sizing.

8.8 . Complete knitted garments – consumer awareness

The primary emphasis of this research project is to develop understanding about complete garment technology, its impact on the product and anthropometric practices. The focus group investigation provided a forum through which to gain understanding about consumers' perceptions of this relatively new method of manufacture.

8.8.1 Garment evaluation

The first task was developed to ascertain if the participants' could identify any of the aspects that make complete garments unique, namely their seamless structure and innovative shaping techniques. The focus group participants were shown a complete knitted garment and a fully fashioned garment, knitted in panels and linked. Both were manufactured by the same company (KM2) and both were trousers (1.1.1.1Appendix I.7 p327 1.1.1.1Appendix I.8 p328). The participants were asked to observe and comment on the manufacture of the garments. The seamless structure of the garment was identified by at least one participant, within 1 minute in all the focus groups. Once the seamless structure has been found, all the participants started to recognise that complete garments are constructed differently. A minority of the participants also noticed the different methods used to create shaping on the complete garment and some used terms such as fashioning and tubular knitting (Focus group transcript 2 p54, Focus group transcript 4 p54, P22, P18 & P19 focus group 4 p52 - 55). This level of knowledge however was not generally shared. When questioned, none of the participants said that they were completely unaware of seam-free knitted garments. In every focus group a minority of participants were very enthusiastic about the garment innovation, using terms like 'clever' and 'amazing' to describe what they saw. Some of the participants were also very intrigued about how the garments were made and asked many questions.

8.8.2 . Recognition of potential advantages

Two approaches were taken to establish whether the participants would recognise or appreciate any specific advantages relating to complete garments. The first question was open and asked participants to suggest any possible advantages, specific to complete knitted garments. Additional examples of complete garments were provided at this point (1.1.1.1Appendix I.4 p324 1.1.1.1Appendix I.6 p326), the dress was particularly well received. Analysis of the discussion generated six coding categories relating to the potential advantages and disadvantages of complete garments (Table 8.15).

Table 8.15 Perceived advantages and disadvantages of complete garments

Coding category	Summary of responses in relation to coding category
Comfort	Recognised to be a key advantage in all the focus groups. Comments specifically noted the seam-free aspect and the potential to eliminate abrasion
Innovative aesthetics	The majority of the participants did not comment about the aesthetics of complete garments however those that did were very enthusiastic. They particularly noted the innovative aesthetic character of the garment. The reduction of seam bulge was also noted.
Drape	It was observed by a minority that the potential to eliminate seams would improve garment drape.
Quality/ longevity	Participants speculated that the elimination of seams may also eliminate the potential for seams to tear or come apart thus extending the lifetime of the garment.
Fit	Only one participant speculatively suggested that the innovative structure of a complete garment may offer the consumer an improved fit.
Additional cost	The suggestion of product innovation provoked some participants to expect increased costs and no real advantage to the consumer.

8.8.3 Ranking the potential advantages

In addition to the open question technique, the participants were provided with a number of prompt words relating to potential advantages of complete garments that might influence them to purchase. These were ranked in order of importance. Table 8.16 shows the findings from each focus group. Table 8.17 shows the combined results calculated in the same way as the results shown in Table 8.11 and Table 8.12.

Table 8.16 Ranking the perceived advantages of complete garments

Order of ranking	Focus group 1	Focus group 2	Focus group 3	Focus group 4
Influential value 1 (most influential)	Improved fit	Improved fit Added comfort	Improved fit	Added comfort
Influential value 2	Added Comfort Waste free manufacture	Innovation Custom made	Added Comfort	Waste free manufacture Improved fit Innovation
Influential value 3	Custom made fashion	Waste Free manufacture	Fashion Waste free manufacture Innovation	Fashion
Influential value 4 (least influential)	Innovation	Fashion	Custom made	Custom made

Table 8.17 The perceived advantages of complete garments (Combined results)

Order of Ranking	Perceived advantages of Complete knitted garments
1 (Most influential)	Improved fit (5)
2	Added comfort (6)
3	Waste free manufacture (10)
4	Innovation (11)
5 (Least influential)	Fashion (13) Custom made (13)

The potential to buy a garment with improved fit was considered to be the most influential advantage to persuade consumers to purchase. Improved fit was not generally recognised however when the participants were asked un-prompted to suggest advantages of complete garments (Table 8.15 p218). There were several comments that recognised the potential for improved drape, indicating that consumers may recognise specific fit related advantages of a seam-free garment. If however they were made aware of fit improvements, it is likely to influence them to purchase. Even once the prompts had been introduced and the participants were introduced to the possibility of fit improvement the participants just agreed that fit improvement would influence them to purchase. There was very little discussion about how or why complete garments might satisfy fit requirements to a higher level than other knitwear. The ranking order is therefore more of a reflection of the fact that garment fit is generally perceived to be of primary importance and concurs with findings prompted by previous questions (Sections 8.4 & 8.5). Only in focus group one was there any discussion to show that the participants might appreciate how a seam-free structure would improve fit and these comments only related to fit improvements through the reduction of bulky seams. These findings suggest that even though garment fit is seen to be a top priority for female consumers, any potential fit advantages would have to be very clearly communicated to the consumer in order to influence purchase.

Added comfort scored only one point below improved fit which concurs with the data from the open question, when all the discussions identified comfort as a potential benefit of seam-free garments (Section 8.8.2). These results indicate that comfort is perhaps the most easily recognisable benefit for the consumer. During the discussion only one participant recognised that added comfort would be of particular benefit for sports or performance garments. A small percentage of the participants said they would not be influenced by added comfort.

The discussion showed that in general the participants did not consider waste free manufacture to be important. Opinion ranged from those who categorically said they would not be influenced, to those who recognised waste free manufacture as an ethical issue, but not important enough to influence them to purchase. Other factors such as cost to the consumer were said to take priority. The following quote illustrates this attitude.

'Well if there were two things [consumer products] on the table that were both matched in everything else then yeah I'd go for something that's more ethical and ecological, it's like everything if the price is right then you'll go for it.' (P17 Focus group transcript 4 p59)

The participants gave innovation a low ranking. It may have been too much of an abstract concept for them to consider as being influential when considering purchase. Phrases such as 'Innovative styling' or 'innovative fit' might have been easier for them to relate to. Certainly a minority of the participants were very impressed with the innovative aesthetics (Table 8.15 p218) and this was not reflected in these results. The majority of the participants were not interested in the idea of a custom made garment. However as the following quote illustrates, a minority of the participants found the notion of custom made complete knitted garments very attractive.

'That would be the height of luxury for me, a knitted garment that was made all in one, [knitted as a complete garment] to my fit. That would be just heaven' (P8 focus group transcript 2 p58)

This enthusiasm was however tempered with a reservation about the cost of a custom made garment which, it was predicted, would be prohibitive. The participants did not appear to relate fashion to complete garments. There was very little discussion about fashion. This may have been influenced by the fact that the complete garments they were shown were not fashion garments and they therefore had no visual prompt to encourage discussion.

8.8.4 Garment style preference

Knitted garments tend to mould to the body. The investigation therefore sought to explore consumers' attitudes relating to knitwear that may accentuate parts of their bodies they would prefer to hide. The participants were asked whether they would wear a number of different types of knitted garments: trousers, dresses, skirts and tops. The results are shown in (Table 8.18).

Table 8.18 Participants' preferences: knitted garment type

Garment type	No. of participants who voted yes	No. of participants who voted no
Knitted dress	18	4
Knitted skirt	15	7
Knitted top	22	0
Knitted trouser	12	9

8.8.5 Knitted trousers

Knitted trousers proved to be the least popular garment style. Two key causes of concern relating to knitted trousers emerged from the discussion: fit and garment care. In relation to fit, it was the degree to which knitted trousers might reveal the body that caused most concern.

‘I’d be too lumpy to wear it on the bottom’ (P6 Focus group transcript 1 p60)

‘I think for someone like me that’s quite bulbous, pair shaped backside and thighs, I think it’s very unforgiving this kind of fabric.’ (P5 Focus group transcript 1 p61)

The analysis of the discussion identified a number of coding categories relating to conditions of acceptability in relation to wearing knitted trousers: type of fit (the degree of tightness), the environment (only in private, in the home), body concealment (use of another garment to hide parts of the body that the knitted garment reveals). In reality, the idea of wearing knitted trousers was not readily acceptable to many of the participants and many of the yes votes (Table 8.18) were conditional, A number of participants also said they would be deterred from wearing knitted trousers because they would stretch and distort at the knee and under the buttocks.

8.8.6 Knitted skirt

The participants in general were slightly less resistant to the idea of wearing a knitted skirt than knitted trousers, concerns identified by those who said they wouldn’t wear a knitted skirt related to body image dissatisfaction. As with trousers conditions were frequently placed on the acceptability of wearing knitted skirts by those who voted yes. The most common being body concealment, and fabric quality (fine gauge opposed to heavy gauge).

8.8.7 Knitted dress

Although only four participants said they would not wear knitted dresses the discussion reflected similar concerns about the relationship between fit properties specific to knitted fabrics and body image dissatisfaction. Some participants however suggested that knitted dresses in particular, could feel sexy and sensual next to the skin. These views had not been voiced for the other types of knitted garments and perhaps indicate that participants have a different emotional response to dresses than other garments. Comments indicate the dresses were perceived to be more representative of femininity. An example of a dress knitted as a complete garment which many of the participants had expressed positive opinions about also influenced them to vote yes.

8.8.8 Knitted tops

In relation to wearing knitted tops, all the participants voted yes to wearing knitted tops and very little discussion was generated with the exception of a small number of participants who said they would never wear polo-necks.

8.9 Knitwear fit preferences: concealment, accentuation

The participants were asked to consider whether they used knitted garments to disguise or accentuate certain parts of their bodies. The data analysis revealed that the participants commonly used clothing to disguise body regions that caused dissatisfaction. Less commonly clothing was used to accentuate regions that caused satisfaction.

'It's like you shape yourself when you dress yourself. You attract the attention to somewhere, or you attract the attention away from somewhere. You just know what to put on which part' (P15 Focus group transcript 3 p80)

Only one participant said that disguising or accentuating were not concepts she considered when choosing what to wear. The body appeared to be treated as a collection of parts, all of which are considered separately before making a decision about what to wear. The participants associated body accentuation, not concealment with knitwear and words like 'revealing' and 'exposing' were used to describe it.

8.10 Fit Preferences in relation to the body

The participants were asked to consider how their attitudes towards their bodies influenced the type of knitwear they chose to wear and whether these preferences had changed over time. They were also asked to select a body shape that they felt most represented their own, from a selection of body shape classification images (1.1.1.1Appendix I.1 p321). Body shape and size appeared to be influential in most of the participants' decisions related to fit preferences. A small minority of the participants claimed to be content with their body shape and size and said that as a consequence they preferred fitted clothes to show their bodies off (P1 & P3 Focus group transcript 1 p66). P4, although not entirely happy with her height, which she described as 'small', agreed with this view. They also collectively agreed that large garments that drape over the body did not suit them. These participants vocalised the most contentment with their bodies and were all a self-disclosed size 8. Two identified their body shapes as top hourglass and one as a rectangle. In contrast, many of the participants vocalised dissatisfaction with their bodies and when asked everyone in focus group 2 said they felt in some way, outside of the norm in terms of body shape (Focus group transcript 2 p72). A number of participants identified specific fit preferences that had been developed as a consequence of body shape issues. Large hips and buttocks had created a preference for A-line shapes to conceal this body region. Those who thought they had overly large busts preferred a lower neckline.

There was also evidence to suggest that some participants had taken advice from friends or television and changed the way they dressed. A self-disclosed size 18, who described herself as having 'a large torso and no hips' and had always worn long loose tops to conceal her torso, had said that she had developed a preference for tighter trousers and short tops, after she had been advised by a friend (P11 Focus group transcript 2 p71). Another participant, a self-disclosed size 14, said that until recently she had always worn clothes that covered her bust because she felt it was too big. She had then realised that a low v neck was more flattering because it made her bust look smaller (P7 Focus group transcript 2 p70). A self-disclosed size 18, who described herself as 'bottom heavy' had developed fit preferences over time and partly in response to the very long tops that she suggested were available in the outsize shops which made her look 'giant'. She now wears shorter tops (P10 Focus group transcript 2 p71). These anecdotes show that women, particularly women who consider themselves to be larger than the norm, are searching for flattering clothing and information that helps them feel comfortable with their body shapes. It also suggests that although there is a strong desire to conceal their bodies, they have become aware that large loose shapes make them feel bigger.

Some participants identified restrictions of choice caused by body shape issues. One participant who disclosed herself as a size 12 for skirts and trousers and a size 14 for tops said she could never find dresses and tops to fit her broad shoulders. Trousers for long legs and fitted jackets that accommodate a large bust were all said to be unavailable or very difficult to find. Other body regions identified as unsatisfactory were the bust, waist, hips and buttocks, thighs, legs, shoulders, back and arms.

Seven participants (all self-disclosed size 14 - 18) said that their preferences have changed as they have become older and less satisfied with their body shape. As a result they avoid wearing tight clothing. One comment specifically suggested that although she used to wear body accentuating knitwear, she would not do so now (P13 Focus group transcript 3 p91). Five participants (self-disclosed size 8-14) however said that their age had not influenced the way that they dressed.

In addition to identifying the body shape that they thought best represented their shape, the participants were asked to select their preferred body shape. An overwhelming majority chose a shape that differed to their initial selection. The most popular shape was the hourglass or the top hourglass.

Table 8.19 Participants self-disclosed body shape preferences

Focus group	Participant	Self-identified body shape	Preferred body shape
1	P1	Top hourglass bust 92	Top hourglass 92
1	P2	Rectangle vii bust 102	Hourglass 102
1	P3	Top hourglass bust 92	Top hourglass 92
1	P4	Rectangle vii bust 92	Hourglass 92
1	P5	Triangle 102 bust	Hourglass 92
1	P6	Triangle 102 bust	Hourglass 102
2	P7	Spoon 102 bust	Hourglass 102
2	P8	Inverted triangle 102 bust	Hourglass 92
2	P9	Rectangle vii larger than 102 bust 16	Hourglass 92
2	P10	Spoon 102 bust 16	Spoon 92
2	P11	Spoon 102 bust 16	Hourglass 92
3	P12	Top hourglass bust 92	Top hourglass 92
3	P13	Top hourglass bust 102	Top hourglass 92
3	P14	Top hourglass bust 92	Hourglass 92

3	**P15**	Spoon	Hourglass 92
3	**P16**	Hourglass 92 bust	Hourglass 92 bust
4	**P17**	rectangle vii and viii bust 102	Top hourglass 92
4	**P18**	rectangle viii 102 bust	Hourglass 92
4	**P19**	Hourglass 102 bust	Hourglass 102 bust
4	**P20**	Rectangle viii bust 102	Hourglass 92
4	**P21**	Rectangle viii bust 102	Hourglass 92
4	**P22**	Rectangle viii bust 102	Hourglass 102

8.11 Development of the theoretical framework

A number of previous studies have focussed on how the consumer evaluates garment fit (Pisut and Connell 2006; De Klerk and Tselepis 2007; Apeagyei 2008). It is generally acknowledged to be a complex process involving a wide number of influencing factors (Loker *et al.,* 2004; Borrogaard 2005; Chatteramann and Rudd 2006). None of this research related directly to knitwear, this study therefore initially explored garment evaluation from a broad perspective. Perceptions relating to both woven and knitted garments were explored and differences were identified. Fit was found to be of primary importance for consumers within the specified age bracket. The development of the theoretical framework for female knit preferences in the UK evaluated the key themes that emerged during the data analysis. Firstly female consumers' understanding of the knitted product was established. This provides a background to the way knitwear is initially perceived. It affirms that consumers are alienated from the knitwear production process and discusses the wider implications of this finding. The next four themes relate more to how a consumer evaluates knitwear as a prospective purchaser and the final stage of the analysis proposes how the unique characteristics of knitted garments impact on the preferences of female consumers which form the theoretical framework

8.11.1 Product alienation

Analysis of the focus group findings indicated that some consumers had very little technical knowledge regarding the garments they wear (Sections 8.2.1 p193 & **Error! Reference source not found.** p**Error! Bookmark not defined.**). They cannot always differentiate between knitted and woven fabric, or identify differing knit structures. They are to a degree, alienated from the manufacturing processes. As a result the task of evaluating fit preferences specific to knitwear presented problems and soliciting opinion on garments knitted on complete garment technology was even more difficult. These difficulties were addressed by the use of visual prompts and group discussion. Although the participants were not directly asked, it emerged from the discussion that those who showed more understanding and recognition of knitted textiles had experience or appreciation of hand knitting. They were therefore familiar with the knitted loop and its manipulation to create pattern and shape. It was however evident from the focus groups that knitting skills are rare amongst this demographic and speculatively, they are likely to be even rarer amongst a younger demographic. If consumers are not generally appreciative of knitting technologies due to a lack of understanding and recognition, promoting novelty due to technological change will be problematic. Therefore it is highly beneficial to gain better understanding of which aspects or characteristics of a garment are important to the consumer.

The data analysis also revealed that the term ‘knitwear’ automatically provoked notions of old fashioned, bulky, garments. This was particularly concerning to those who had self-disclosed as over a size 14 who were wary of garments that increased their body size. The term ‘knitwear’ was not generally associated with fine gauge knitted or jersey garments. This finding supports the use of very clear visual prompts to ensure that appropriate responses are solicited when using terminology that prompts a number of confusing responses.

8.11.2 Garment characteristics that influence preferences

De Klerk and Tselepis (2007) found that consumers’ preferences in relation to clothing includes the assessment of a number of functional and aesthetic garment characteristics. This study compared responses relating to knitwear and woven garments to ascertain whether female consumers seek a specific set of garment characteristics when purchasing knitwear. Data analysis revealed that women are very clearly seeking garments that fit well. Fit was identified to be the most important characteristic for both woven and knitted garments. The analysis also revealed that good fit was very strongly associated with the idea of garments that flatter or improve perceptions of the body. (Section 8.5 p203). The characteristics that varied the most were warmth which had more associations with knitwear and sex appeal which was rated as a higher priority for woven garments. Comfort rated only very slightly higher as a priority for knitted garments and somewhat surprisingly, the majority of the comments failed to acknowledge that knitted garments are less likely to restrict movement. Data analysis found that an additional characteristic specific to knitted garments was discussed. The aesthetic quality of shaping (narrowing and widening) drew some enthusiastic attention and although consumers were not informed about the technicalities of shaping, a small number were very appreciative of the aesthetic value. The comments showed that it was shaping aesthetics that provided visible evidence of the innovation.

A previous study indicated that fashion influences the process of fit evaluation (Apeagyei 2008) and data from the case study findings also revealed that garment fit was modified to conform to fashion demands. Focus group analysis provides evidence to show that the women in this particular demographic were generally resistant to the concept of fashion which was associated with built in redundancy and an inhibitor to an individual's ability to self-express. It was therefore difficult to prompt discussion about the relationship between fashion and fit preference. There was evidence to show that because for knitwear functional requirements, specifically warmth and comfort were prioritised over fashion, classic knitwear styles were considered to be preferable Although colour was acknowledged to be influential in general, no perceivable relationship between colour and fit emerged.

8.11.3 Shaping the body

This study provides evidence to show that the concept of fit was generally a high priority for female consumers and that fit satisfaction was dependent on the extent to which a garment was judged to improve perceptions of the body. Previous studies have suggested that it is common for individuals to want to disguise or emphasise certain body characteristics depending on how satisfied they feel about themselves (Pisut and Connell 2006; Apeagyei 2008). This phenomenon has never been reviewed in specific relation to knitwear before. The focus group analysis provides further insight into how the differing properties of a knitted garment impact on the ability to emphasise and disguise.

The analysis revealed that knitted garments were not associated with body shape improvement because of the propensity of knitwear to mould around the body and emphasise body regions that cause dissatisfaction. Draped knitwear styles that can disguise the body were identified as flattering and a small number of participants predicted that complete garments would drape particularly well due to their seamless structure. There was some recognition that clingy, fine, knits can look sexy, although these comments related to representations of a projected idea of the feminine body, rather than to their own personal preferences. The discussion also indicated that revealing garments were often equated to sexualising the body and appearing to be dressed in an inappropriately young style, neither of which were desirable.

In addition to the notion of disguise, the analysis revealed that women do occasionally also seek clothing that constricts body regions and used clothing to shape their bodies into what was perceived to be a more attractive shape. It is significant that woven garments were associated with being able to constrict the body, were also judged to have a greater association with the term body shape improver than knitted garments. The analysis also revealed that consumers are at times prepared to sacrifice comfort if restrictive fit provided sex appeal and desirable body aesthetics. Perhaps because of this link sex appeal was ranked as a higher priority for woven garments than for knitted garments.

One particular discussion focused on a knitted garment worn by a participant. This enabled all involved to refer to a tangible prompt that directly showed the relationship between the knitted garment and the body. Participants found the moulded fit around the shoulders, arms and upper chest attractive. The loose draping around the lower body was also considered preferable. The participants clearly preferred to wear closely conforming knitwear around certain body regions, (upper body) but not others (lower body). This finding is indicative that it is not necessarily correct to suggest that larger sized consumers are likely to have an aversion to knitted garments that mould to their body (Borrogaard 2005). It is perhaps more accurate to propose that female consumers are only satisfied with a moulded fit around body regions that they are satisfied with.

8.11.4 The relationship between size, shape and fit preference

Studies previously reviewed have identified that weight norm is decreasing (Section **Error! Reference source not found.**, p**Error! Bookmark not defined.**). Female consumers, who have been found to be increasing in size are therefore assessing themselves against a beauty ideal that is becoming increasingly thinner. The focus group data identified that dissatisfaction with the body, frequently related to the notion of size and larger than the weight norm was perceived to be dissatisfactory. In relation to body shape, female consumers were more dissatisfied the more they perceived themselves to deviate from the ideal body shape. In addition to this, the analysis revealed that consumers develop preferences as a result of their body shapes. Only two participants were completely satisfied, they were both self-disclosed size 8 and had identified their shapes as a top hourglass and a rectangle. Their perceptions of their bodies correlate more closely to the current weight norm than the other less satisfied participants. They were the only participants who preferred to wear clothing that accentuated their bodies. One other participant claimed she preferred fitted clothing also a size 8 who had identified her shape as a top hourglass. She was however dissatisfied with her height and was wary of clothing that was loose and draping as it made her feel short.

Body shape dissatisfaction was invariably attributed to body regions that were considered to be too large, flabby, or protruding and included bust, waist, hips, buttocks, thighs, legs, shoulders, back and arms. When asked to select their preferred body shape, only one of the participants did not state a preference for either the hourglass or the top hourglass shape. Only seven participants selected the hourglass or top hourglass as the shape that most represented their own body indicating that the fifteen remaining participants were dissatisfied with their body shape. Pisut and Connell (2007) conducted a large scale survey which identified which body regions the participants were most dissatisfied with, within a female population. The focus group analysis clearly revealed that fit preference relates very closely to body shape satisfaction and fully justifies the drive to acquire this type of knowledge. If female consumers disguise body regions that cause dissatisfaction, knowing which body regions are of most concern within a given population could inform design practices. The evidence from the focus group suggests that this would be particularly beneficial for knitwear designers because knitwear was automatically associated with emphasising the body.

Although a knitted garment can conform to a variety of body shapes, the evidence shows that this does not mean it will be judged to be of satisfactory fit. The perception that greater garment extensibility improves garment fit, held by the machine builders and the case study manufacturers (Sections 6.4, p114,) is therefore not necessarily an accurate reflection of female consumer preferences. It has also been established that female consumers evaluate garments in terms of the impact they have on the body and seek garments that flatter their bodies (Table 8.13, p205). In specific reference to knitwear this equates to draping to disguise unsatisfactory body regions and only accepting a moulded fit around body regions that are deemed satisfactory. The analysis also revealed that this desire to disguise the body is complex as overly loose garments were perceived to add bulk. Knitwear manufacturers therefore need to be aware that although female consumers may not generally expect knitted garments to flatter their body shape, body shape improvement is considered to be a priority when selecting garments. It would therefore be of benefit to consider how to create garments that flatter the female body at the initial stages of product development. Anthropometric data would need to inform this approach.

8.11.5 The impact of fabric properties: Garment type

Differing garment types; skirts, dresses, trousers and tops all relate to specific body regions. Analysis of the focus group data indicates that female consumers relate differently to each specific body region. Garment styles that conform closely to regions of the body that generally caused high degrees of dissatisfaction were found to be less popular. The comments suggested that it was the emphasis of the stomach, buttocks, hips and thighs that cause the greatest concern to a considerable proportion of the participants. It is perhaps not surprising that knitted trousers were the least popular style. Trousers define each leg separately and therefore will accentuate every part of this body region, including between the upper thighs. An additional concern specific to trousers was the propensity of a knitted fabric to deform at the knee. The participants were slightly more accepting of knitted skirts which emphasise less body regions than trousers. Participants registered some concerns about knitted dresses in terms of body emphasis, but they were considered to be more acceptable than knitted skirts. It was recognised that dresses can fit loosely around the body drape from the shoulder. The case study data showed that complete garment technology is capable of producing particularly successful dresses. The development of knitted dresses that consider the consumer and their fit preferences could find a ready market. Knitted tops were the most accepted garment style. Tops like dresses can fit tightly or loosely around the body and clearly do not emphasise the lower body regions.

8.11.6 Sizing dissatisfaction

In relation to size provision, there was a definite split between the size 14 and under groups who were generally satisfied with the sizing provision of knitwear and the over size 14 groups who were dissatisfied. Larger consumers do not appear to be served well by current sizing systems. The effect of this on women has been found to be dissatisfaction with their own bodies (Grogan 2008). In support of this claim, the discussion about sizing provoked many of the participants to reveal body regions that cause dissatisfaction, perhaps indicative of the fact that women are forced to judge their bodies against an unrealistic and rigid standard, caused by sizing systems that are based on one body shape. Despite efforts to increase accessibility to appropriate anthropometric data by conducting large scale sizing surveys (Bougourd *et al.* 2000; Bodymetrics 2005), the focus group analysis suggests that sizing systems utilised in the UK do not appear to provide clothing to satisfy women's fit demands.

Inconsistencies between size coding systems used by clothing providers also clearly caused dissatisfaction amongst the focus group participants. The issue of how to communicate garment size to the consumer is unresolved. Previous studies have proposed that size labels should provide the consumer with clear guidance on the key body dimensions that the garment is supposed to fit (Chun-Yoon and jasper 1995; Winks 1997). The focus groups analysis indicates that consumers are resistant to this idea. The discussion however was based on the perception that knowing the key dimensions would exclude consumers with different body shapes from trying the garments (Section 8.6.3 p213). As the only change from current practice would be that the consumer has more information on which to base their choice, this opinion is ill-informed and is indicative that effective sizing communication to consumers would be difficult to achieve. There was some evidence from participants with experience of buying jeans and on-line purchases to suggest that consumers will make efforts to inform themselves of their key body dimensions if it decreases time spent in the fitting room or the necessity to return garments. A sizing system that provides key body measurement information would emphasise the inherent limitations within sizing systems that are currently obscured. This is likely to inhibit retailers from willingly adopting such a system.

Some coding systems (single numeric and European numeric) were identified as being less meaningful then others (double numeric and descriptive). The globalisation of the clothing industry presents consumers with a confusing amount of diverse information which is unsatisfactory both for retailers and consumers. This issue was also clearly problematic for KM2 and KM3 who were supplying garments to an international market (Sections 7.4.6 p141 & 7.11 p187). Although the focus group participants were most familiar with double numeric and descriptive size codes, they were clearly aware that there is no transparency as to the actual value of these sizes in terms of body dimension. As a result some consumers perceive the codes as completely irrelevant. To satisfy the consumer, focus group data suggests that the unilateral adoption of one size coding system that maintains a consistent dimensional relationship with a transparent size chart.

Although vanity sizing has been blamed for increasing sizing inconsistency on the high street (Treleavan 2007) there was clear evidence from the focus group analysis that purchasing a garment with a size label indicating a smaller size than expected increases feelings of well-being, particularly for female consumers over a size 14 and it is perhaps understandable that retailers adopt systems that flatter women. It is however a false measure, if sizing systems are used as a marketing tool in this way they become meaningless. A much better approach would be to produce garments that flatter and fit the body.

8.11.7 Evaluation: the potential benefits of complete garments

A considerable number of reports predicted that utilisation of complete garment technology would provide benefits including: improved fit, added comfort, innovation, waste free manufacture and the ability to provide customisation (Kurasano 2000; Hunter 2004a; Hunter 2004b; Spencer 1996; Gibbons 1997b; Mowbray 2002; Nakashima and Karasuno 1996; Stoll 2000). The focus groups provided opportunities to solicit consumer perceptions in relation to these potential benefits. The analysis indicated that the prospect of garments with both improved fit and added comfort were highly rated as potential benefits. Added comfort was the benefit that consumers found easiest to discern. It is therefore likely that any development for garments that require specific comfort requirements, such as sports or undergarments would be readily appreciated by consumers. This finding indicates that the consumer would recognise claims from the machine builders (section 6.4.2 p114) and the case study interviewees (Section) particularly regarding added comfort.

The proposal that consumers would be attracted to the concept of waste free manufacture (Section **Error! Reference source not found.** p**Error! Bookmark not defined.**) was not found to be particularly attractive to the focus group participants who were suspicious that it would incur added cost. Although a few participants spoke favourably about the concept of customisation, the discussion indicated a close association with luxury and was predicted to be unattainably costly. Innovation as a benefit was only perceived to be attractive to a small but very enthusiastic minority. These consumers did recognise the shaping innovation on the sample garments provided and registered a high degree of appreciation for the aesthetic value of the shaping innovation.

8.12 The theoretical framework for Knitwear preferences

Analysis of the focus group data used coding to identify key concepts. To build theory, relationships between the concepts have been identified and a number of hypotheses have been proposed. These provide insight into how and why consumer preferences relate to knitwear and how this information can create meaningful theory that can inform industry practices. It also aims to build a foundation on which to base further research and to inform the development of the conceptual model Figure 9.14 p264. In the following sections, the term consumer relates to a female consumer who falls within the ages of 40 and 55

Analysis of the focus group data revealed that to satisfy female consumers, knitwear must first and foremost provide them with a flattering fit. The idea of flattering was bound up with perceptions of the body including size, shape and body image. The desire to disguise certain body regions and only emphasise regions that do not cause dissatisfaction is critical when relating fit satisfaction to knitwear that moulds around the body. The theoretical framework evaluates the relationship between these body related issues and develops a set of objectives to provide some basic guidelines for product development

8.12.1 Preferences related to fit of knitted garments

In relation to knitwear fit preferences the body tended to be viewed as a set of component parts that related in size to a perceived body ideal. Body regions that were not in proportion with the ideal were identified as a cause of dissatisfaction. A hypothesis proposes that the more a body region deviates from the ideal, the greater the dissatisfaction it induces (Figure 8.1).

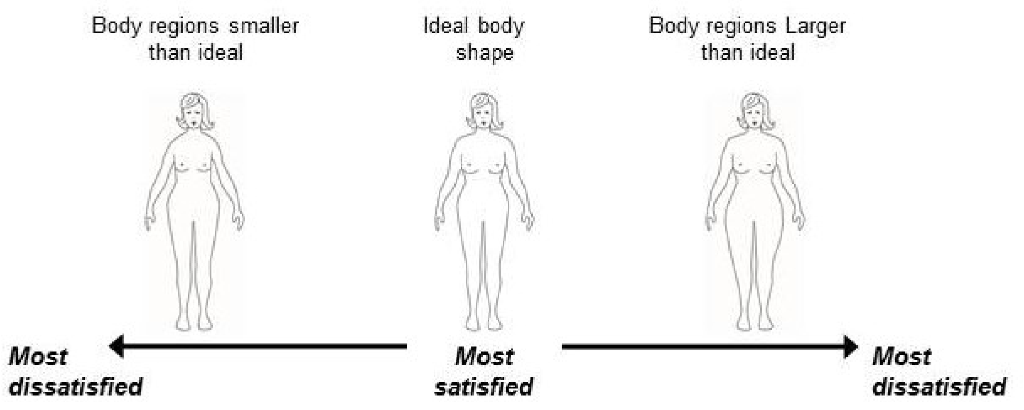


Figure 8.1 Body shape satisfaction scale

Although knitted garments can stretch to fit a diverse number of body shapes and sizes this clearly does not automatically create satisfaction. Knitted garments that fit and drape strategically to specific body regions generate the most satisfaction. Figure 8.2 identifies the key factors relating to the garment and the body that influence knitwear fit satisfaction as: extensible fit, loose fit, body emphasise, body disguise, body regions that cause satisfaction and body regions that cause dissatisfaction, a hypothesis proposes that consumers prefer to wear knitted garments with extensible fit only on body regions that cause satisfaction and knitted garments with a looser or draped fit on body regions that cause satisfaction.

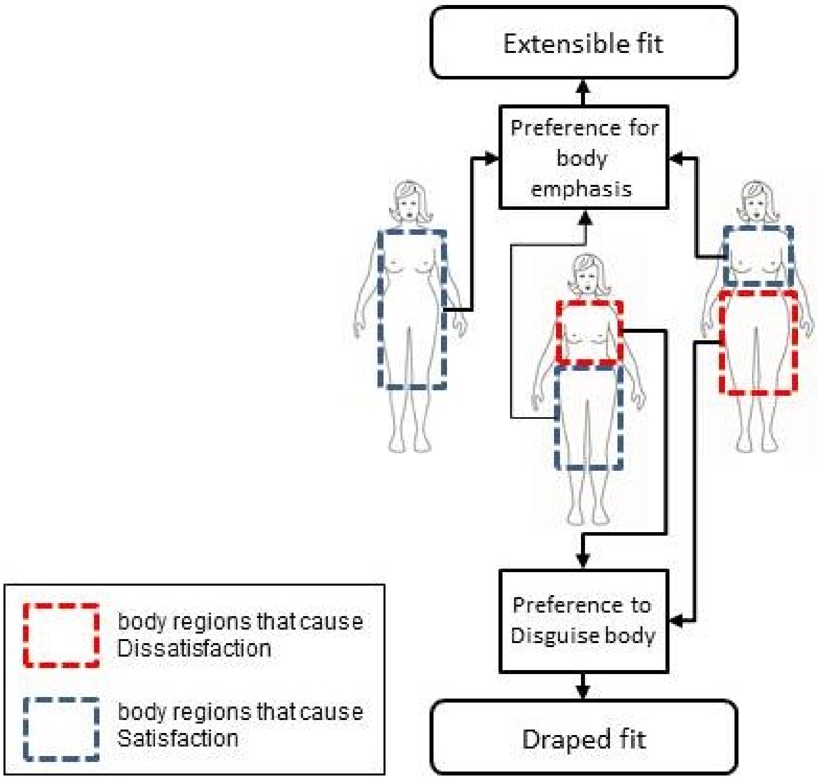


Figure 8.2 Consumer preferences: flattering knitwear fit

To provide further insight the analysis related to the acceptability of garment styles (Section 8.5 p203) revealed that knitwear styles for lower body regions were less accepted than knitwear styles for the upper body. Analysis of the discussion data indicated that this was because female consumers were less satisfied with lower body regions. A further hypothesis is that consumers are less satisfied with lower body regions than upper body regions.

8.12.2 Sizing issues relating to consumer satisfaction

Four key sizing issues were found to influence satisfaction: sizing provision, sizing inconsistency, size code inconsistency and vanity sizing. The consumers' body size was also found to influence the relationship between each of these sizing factors and have an impact on the levels of satisfaction gained. The relationship between sizing provision and body size has been determined and a hypothesis proposes that: the greater the consumer deviates from this industry imposed body ideal the greater the dissatisfaction with sizing provision (Figure 8.3).

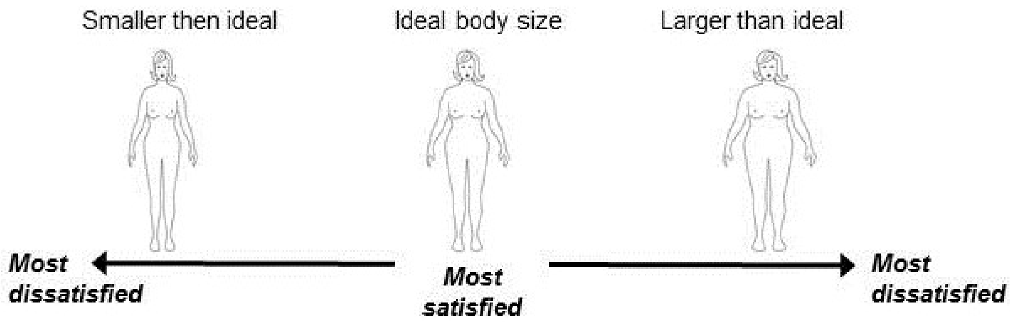


Figure 8.3 Body size satisfaction scale

The second set of hypotheses relating to sizing preferences (Figure 8.4) identifies a slightly differing set of causal links between levels of satisfaction gained, sizing issues and consumers of different sizes and propose that:

Consumers who are smaller than the ideal size are dissatisfied with sizing provision, inconsistent sizing and inconsistent size coding.

Consumers who conform to an ideal body size are satisfied with vanity sizing, and sizing provision but dissatisfied with inconsistent sizing and size coding

Consumers who are larger than the ideal size are satisfied with vanity sizing and dissatisfied with sizing provision and inconsistent sizing and size coding

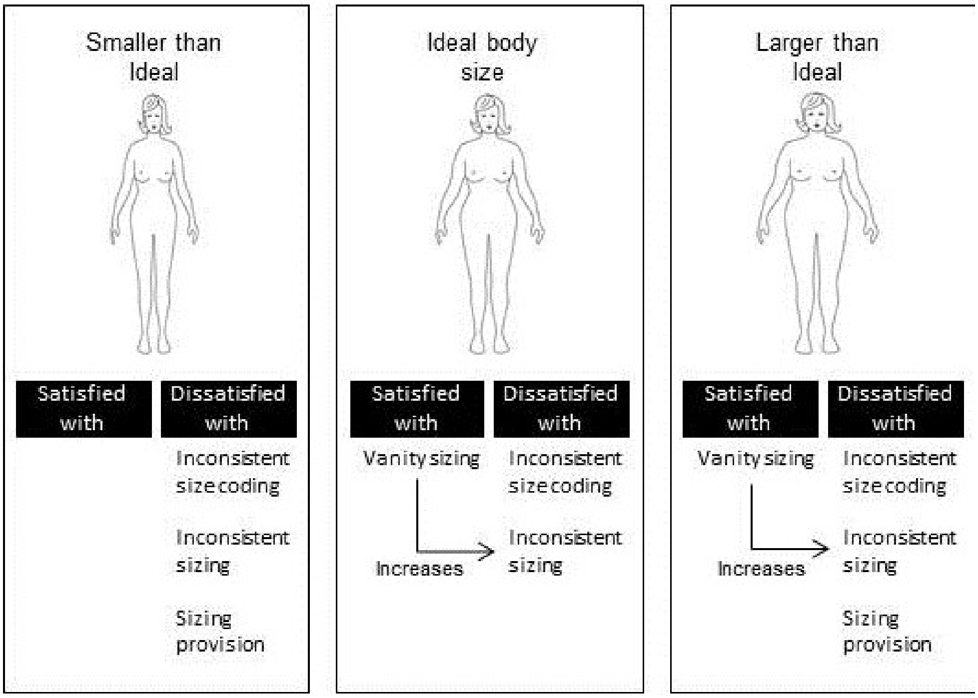


Figure 8.4 Consumer preferences regarding knitwear sizing

8.12.3 Shaping

In general female consumers were found to be unaware of shaping techniques used on knitted garments and tended to be disassociated from the knitting process. Some consumers were very appreciative of the aesthetic qualities of fashioning, integral shaping and narrowing and widening.

The final theoretical framework provides a figurative representation of the relationships between the garment characteristics that influence female consumers to purchase knitwear. Central to this figure and most prominent is the concept of flattering fit. The figure proposes five additional garment characteristics that were less important than the idea of flattering fit but still influential to female consumers knitwear preferences. Warmth and comfort are functional requirements that were found to be closely associated with knitwear. It is acknowledged that warmth is a specific aspect of comfort. A relationship between comfort and flattering fit is also included as the consumers recognised that good fit should not sacrifice comfort. Additional bulk has been included as a negative garment characteristic, for knitwear bulky garments are associated with warmth. Shaping aesthetics were regarded by some as attractive. There is a relationship between shaping and the ability to provide consumers with flattering fit. Colour was acknowledged to be influential but no relationship between colour and other characteristics was identified.

Theoretical framework for preferences of UK female consumers relating to knitwear

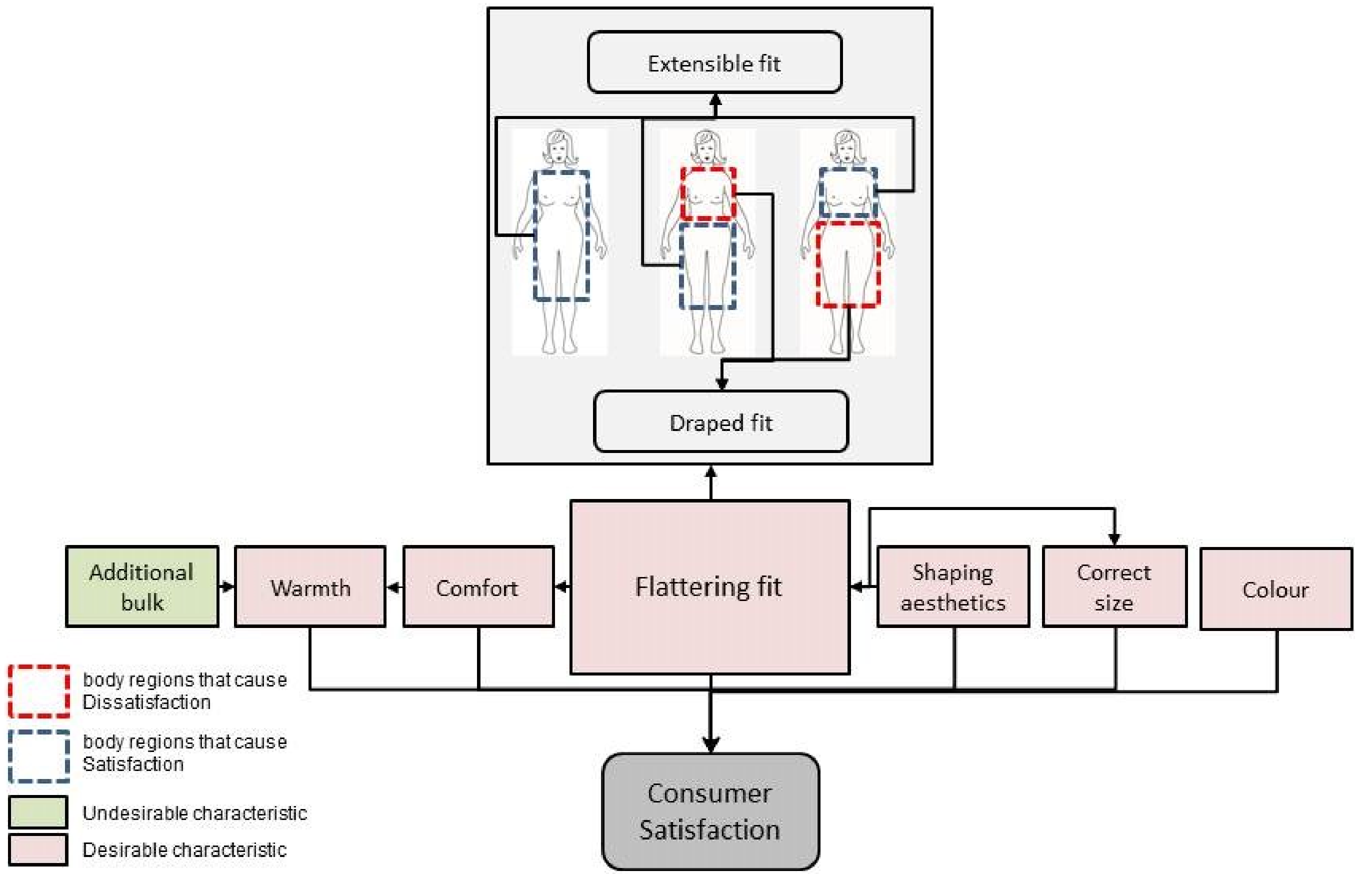


Fig 8.5

Chapter 9 Development of the conceptual model

9.1 Introduction

This chapter evaluates the findings from the previous research phases in relation to the utilisation of anthropometric data within the development and production processes of complete garment manufacture. The final stage to develop the theoretical framework for knitwear preferences expounds the initial analysis (Chapter 8 p189) and evaluates the emerging themes within the wider context which acknowledges themes generated from previous theoretical study within the field. The development of the conceptual model evaluates the process leading to the construction of a diagrammatic representation which synthesises and analyses the research findings holistically. [Finish after say how the model was developed]

9.2 Utilisation of complete garment technology in the UK

Analysis of data from various sources revealed that only a small percentage of UK knitwear manufacturers (5%) were utilising complete garment technology (Table 5.6 p108). Interviews with representatives from the machine builders revealed that the two primary factors inhibiting UK investment were: high costs and the dependency on highly skilled technicians. These findings concur with reports found in industry journals (Mowbray 2003a; Mowbray 2005; Siddons 2007). The UK knitwear industry was clearly perceived to be an industry under threat and therefore not a high sales priority for MB1 or MB2. Analysis of the interview data with MB1 indicated that in a highly competitive market, where imported knitwear has driven down perceived product value, strategies that involve high investment are likely to be considered extremely risky. UK manufacturers are therefore more likely to be persuaded to invest in technology that clearly decreases production costs and increases the ability to compete on price. The interviews with the machine builders however, revealed that at that time, knitting garments on complete garment technology extended the knit times, in comparison with traditionally knitted garment panels. Therefore, although post-production procedures are eliminated, production times do not necessarily decrease and there is not clear reduction in production costs. UK manufacturers who had invested had done so because of skills shortages for post-production procedures.

The key findings from the first phase of the research that investigated the views from the machine builders forms a foundation for the conceptual model (Figure 9.1). This initial model illustrates the situation in the UK where knitwear manufacturers although threatened by strong competition, have been reluctant to invest in complete garment technology. The model illustrates the key deterrents to UK implementation identified by the machine builders and the key reason for investment in the UK (Sections 6.3 p113 & 6.6 p118).

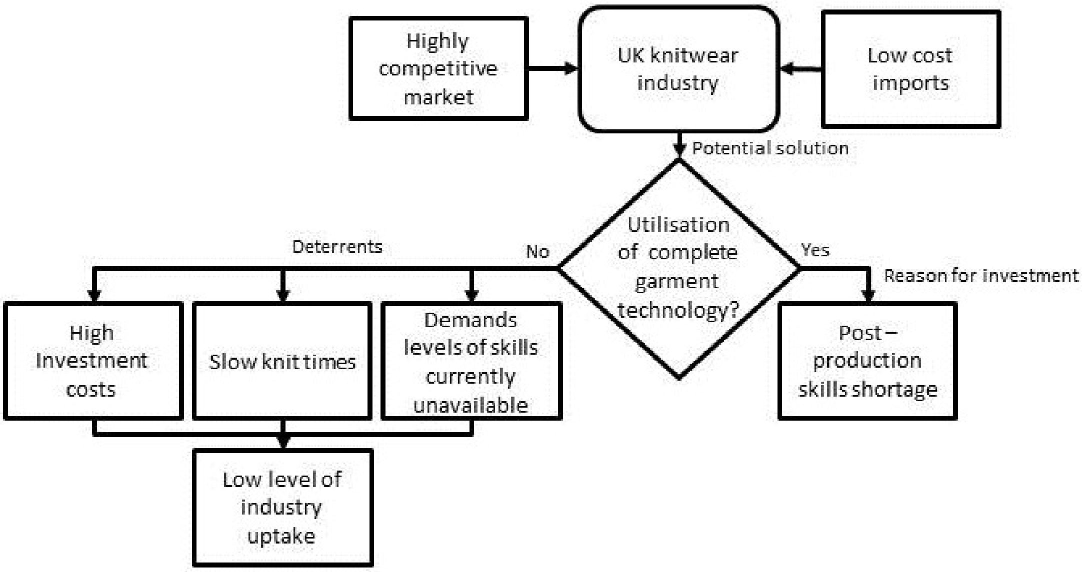


Figure 9.1 Complete garment technology: Inhibitors to UK investment

9.3 Cultural issues: the impact on product development

This study provides clear evidence to support the claim that the skills and knowledge to enable successful implementation of complete garment technology are currently unavailable in the UK (Brackenbury 1992; Black 2001; Mowbray 2003a; Sayer et al. 2006). A substantial amount of additional evidence from the case study analysis determines where these skills gaps were found and how they impact on product development and subsequently the garment itself. The product development team were informed by their skills and experience within the fully fashioned knitwear industry. Previous studies have argued that manufacturers producing fully fashioned garments have had a tendency to be conservative (Brackenbury 1992; Guy 2001). The influence of this traditional, conservative knitting culture on working practices was tangible from the case study analysis. There was clear evidence to show that product development teams were, in the absence of appropriate information, drawing on outmoded and unsuitable methods to inform the development of complete garments.

9.3.1 The technician

An evaluation of the roles within the product development team revealed that the technicians' are solely responsible for developing the knitting programme. Essentially they were creating the garment shape. Traditionally new fully fashioned knitwear styles are based on a garment template which is modified. As a result there are a limited number of well recognised fully fashioned classic styles (Mills 1965; Walsh 1966; Power and Otieno 2007; Power 2007) (Table 3.1 p53). The literature produced from a technician's perspective tends to present formulaic methods to achieve pre-established garment styles (Mills 1965; Walsh 1966; Kumar Puri 2010). Having developed their practices within this traditionally conservative industry, where shaping is applied using standard methods, the technicians were evidently challenged by having to conceptualise the garment three dimensionally. The case study analysis clearly indicated that the technician's skills and knowledge influenced the degree to which a garment fits the body. Knowledge of where to include fashioning to improve fit was developed empirically and therefore the more experience gained the more likely fit will improve.

Creating programmes for complete garments involves calculating how to join the body to the sleeves, which requires both consideration of loop placement on the needle beds an understanding of how create 3D shapes that relate to the body. Within the product development process for woven garments this is the pattern cutting role. Case study analysis revealed that there was a skills gap within knitwear product development and the equivalent role to a pattern cutters is absent within knitwear product development. The use of templates minimise the consequences of this skills gap, however it was evident that garments had been developed without templates, a process had been excessively laborious with a high risk of generating unsatisfactory results. The technicians had relied heavily on an historical understanding of shaping fully fashioned garments and applied this within the tubular structure. The relationship between the garment and the body was not defined until the fit trial was conducted. Data analysis provides further evidence to suggest that a number of fit problems which were thought to be caused by shaping limitations could actually be solved if a more sophisticated understanding of how to generate 3D shape to fit the body was applied. One example is the claim that only shallow armholes can be achieved because of machine limitations regarding shaping angles. This example demonstrates that the shaping is only being considered on a 2D level on the edge of the armhole. Armhole shaping occurs at the side of the bust and fit problems should consider how the curvature of the bust impacts on armhole shape and fit. If shaping was applied using methods discussed in previous studies (Haffenden 2010; Spencer 2001) to add some bust suppression, the required fit at the armhole is more likely to be achieved. This approach to problem solving can only be adopted if an understanding of the 3D constructs of the body is applied.

Figure 9.2 illustrates the current situation

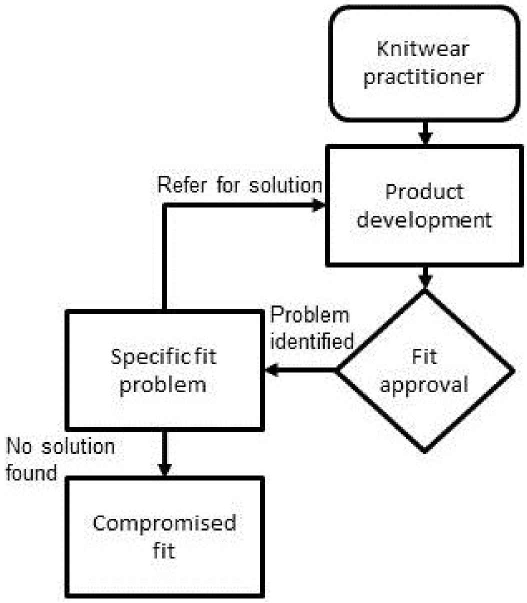


Figure 9.2 Current limitations found in the product development process

The technician at KM1 had identified a need to apply body dimension that has not previously been used (Figure 9.3 indicated in red). If the complete garment is knitted as one tube after the sleeves and body have been merged at the underarm, knowledge of the full dimension around the upper chest and the upper arms was thought to be helpful. To obtain consistency when measuring this body region however is likely to be problematic as any movement of the arms will impact on the final measurement. This acknowledgement does however demonstrate that the development of complete garments needs a new approach which includes an evaluation of the body and the identification of the key body dimensions needed to define complete garment dimension.

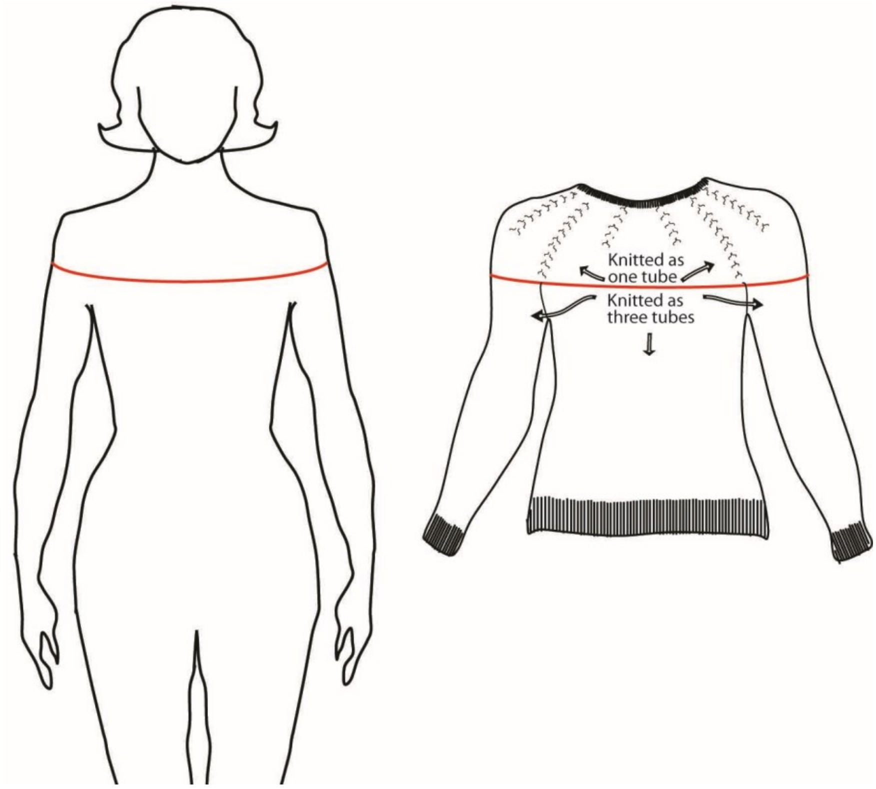


Figure 9.3 Identification of potential key dimension

Garment observations (Table 7.14 p153, Table 7.15 p154 & Table 7.16 p155) provide evidence that a more sophisticated understanding of pattern cutting methodologies that create 3D garment shape, such as draping and the creation of flare (Aldrich 2004; Di Marco 2010) would also benefit the complete garment development process. This approach is likely to challenge traditional thinking where the tendency is to focus on how to achieve course and wale alignment between the component parts of the garment (Kumar Puri 2010). This type of apporach may actually restrict design experimentation to create garments that fit the body in innovative ways. If for instance a designer's aim is to ease a sleeve into an armhole to create a raised sleeve head, this will prevent course and wale alignment.

To create garments with satisfactory fit it is generally recognised that an understanding of the body is necessary (Otieno 1999; Gill, 2008; Jenkyn Jones 2005). The female body is a complex geometric shape which changes through movement. Without a methodology to follow that is more than just replicating formulaic methods, it is difficult to understand how knitwear development can progress.

9.3.2 Designers

A previous study claimed that complete garment designers were constrained by their lack of skills and suggested that designers should be equipped to be able to create the garment programmes (Siddons 2007). Case study analysis provides substantial evidence to show that this would require a cultural change within an industry where traditionally roles have been acknowledged to be very separate. The predominantly female design role does not utilise what are predominantly male skills (Eckert 2001). Furthermore, it was evident that the utilisation of complete garment technology had actually exacerbated the role differentiation. The designers' specification documents were frequently criticised for being inaccurate and technicians openly re-interpreted the information provided in line with their own heuristic knowledge. Eckert's (2001) study conducted within knitwear companies in the UK and Europe found very similar problems and argued for tools and methods to facilitate knitwear designers in order to improve the accuracy of specifications for knitwear. This communication problem is illustrated in articles by Power (2008) and Kumar Puri (2010), both of which refer to methods to calculate how to determine the armhole depth, a measurement which is not traditionally included on fully fashioned specification documents. Power (2008), using empirical knowledge, advises that a negative dimensional adjustment should be made to the garment size chart in order to allow for the shoulder to stretch once the sleeve is attached.

The complete garment designers participating in the case study research who, according to Guy (2001), would have already been hindered by a lack of technical skills within their previous roles as fully fashioned designers, were further handicapped by a complete lack of specific training for the new technology. Therefore although it has been widely acknowledged that complete garment technology provides new ways to shape and style knitted garments (Karasuno 2000; Shima 2000; Power and Otieno 2007), this study asserts that the designers were clearly not able to realise this potential and that utilisation of the technology had in fact exacerbated long established problems within the product development teams.

A number of instances within the case study analysis illustrate this lost potential. The designers constantly complained that they could not develop specific styles and silhouettes because they had been informed by the technicians that they were beyond the limits of the technology. Failure to create satisfactory puff ball (A fashion silhouette with 3D, rounded structure) silhouettes was just one example of the designers' inability to influence the development of shaping. At KM1, where experimental development was evidently considered too costly to risk, puff ball silhouettes, although identified as on trend by the designers, had not been attempted. KM2 had produced a range of puff ball shaped garments that were not completely satisfactory and observational analysis provides clear evidence that the shaping had not been conceptualised to produce a 3D structure (Table 7.15 p154 & Table 7.21 p165). KM3 had also produced a puff ball styled garments with support from the Shima Seiki technicians. This was the only development that was claimed to be successful. A number of additional potential design capabilities were evident from the case study analysis. Complete garment technology can for instance create integral gathers. The digital stitch control provides opportunities to control stitch size which can increase or decrease the dimensions. In the hands of an informed and creative product development team this capability could be exploited in many ways to create novel garment shapes and different types of fit. These opportunities are lost unless designers develop the necessary skills and knowledge to apply them and time is provided for research and development.

Designers are acknowledged to be visual thinkers (Eckert 2001) and will be much more sympathetic to the task of conceptualising the relationship between a 3D garment on the female body. This study provides good evidence to suggest that designers should have full working knowledge of how to manipulate the stitches within the tubular structure of the complete garment. This knowledge alone would not however be sufficient to enable designers to really start to conceptualise within the 3D knitwear environment that is complete garment technology. An evaluation of the processes that are conducted within the product development cycle (7.11 p187) revealed that a process to apply anthropometric data to the garment, the equivalent to pattern cutting in woven garment construction does not occur and the designer visualises the garment within a 2D environment. This study asserts that designers who are expected to initiate the development of garments need to be able to fully relate the garment to the body within a 3D environment. Traditional knitwear product development practice which modifies pre-established garment templates constrains knitwear design within a framework of pre-established shapes and silhouettes. The utilisation of new technologies demanding new approaches, should provide opportunities to lift this constraint. The case study analysis certainly provides considerable evidence to show innovative garment design is possible. However much of this innovation was introduced externally as the designers only opportunity to realise machine potential was to take inspiration from the sample garments produced by the machine builders. It was clear that UK designers were evidently still contending with having very little ability to influence the finished product.

9.3.3 Cultural influences: quality and finishing

There was clear evidence to show that traditional fully fashioned methods were not only adversely influencing the design and development processes. Case study analysis revealed that traditionally knitwear is pressed flat on 'boards' or frames that have been manufactured to specific garment dimensions. This practice presented a problem for complete garment manufacture. Not only did the diverse range of garment styles render the production of boards commercially unviable but some of the more innovative garment styles were unsuitable for this traditional pressing method. Yarn dyed knitwear was evidently less reliant on the pressing process to ensure a quality finish. For piece dyed knitwear, the pressing process was tightly controlled and perceived to be instrumental in the retention of correct garment dimension. The high tech framing system using laser beams to monitor garment dimensions utilised at KM2 demonstrates the importance of the pressing process within fully fashioned knitwear manufacture. Observational analysis of the garments from KM2 revealed that they were pressed flat with clear crease marks visible. This had a radical impact on any 3D shaping (Section 7.12 p188). KM3 used a Hoffman press, another tool which can only be used to press garments flat. Appropriate methods to press 3D knitted garments were not to be available. (Figure 9.4) illustrates the inadequacies of the pressing process

Figure 9.4 Implications of the pressing process

9.3.4 Machine builders

The case study analysis revealed that it was the machine builders who were the principal influencers of complete garment development. The machine builders conducted all the training and their technicians supported the UK manufacturers for two years after the machinery had been implemented. They were therefore the sole provider of information regarding specific complete garment development. The machine builders considerable investment into garment development was evidently further influence on the design and development practices within the UK companies (Section 3.6.3 p57). These sample garments were the only examples the designers had to help them develop skills. This study proposes that there was an over reliance on the machine builders to develop and disseminate the required.

In terms of garment development the aims of the machine builders, who primarily want to promote and market their knitting machines were clearly different to the aims of the UK knitwear manufacturers who considered it to be critically important to produce product ranges that reflected their individual brand's identity (fast fashion, luxury Scottish heritage and classic British heritage). There is also evidence that culturally, the machine building industry, is highly proprietorial and patent their most innovative garment development (Section 3.5 p53). Therefore, Information will only be released in formats which will protect the machine builders' intellectual property rights. To provide a different perspective on skills development, a previous study argued that educational institutions need to develop specific courses with a focus on complete garment technology (Sayer et al. 2006). Certainly as the design process initiates product development, it is short sighted to disregard the educational development of the designers. Training that is conducted independently from the machine builders would provide UK manufacturers with an increase autonomy over design and development processes. However If the specific skills needed to exploit complete garment technology are unavailable within the industry, it is doubtful that they are widely available for training and educational purposes either.

Data analysis from the interviews with the machine builders clearly showed that they did not appreciate the use of anthropometric data (Section 6.4.3 p115). Their perceptions in relation to knitwear development concurred with the case study data that it is pre-established garment measurement that determines the development process, not body measurement data application. The training provided by the machine builders clearly did not acknowledge methods of applying anthropometric data to the 3D structure of the complete garment. It is also highly likely that the processes used to develop the machine builders' sample garments are informed by an appropriate evaluation of the body.

9.3.5 The retailer

the complete garment, therefore was not recognised for its unique qualities by their retail customers. KM1 had developed their product range specifically for UK high street retailers and had to respond to customer demand which was trend led. Exploiting machine capability and innovation was perceived to be secondary to the creation of a fast fashion product.although the interviewees clearly recognised the potential to develop niche products within new market sectors this opportunity had not been pursued by KM1 management.

Figure 9.5 conceptualises key influential factors on both the designer's and the technician's practices which result in a problematic route to original garment creation. The figure indicates that the designer has very little input to guide practices. The technicians' initial training was dependent solely on the machine builders input and was considered to be limited and not entirely relevant to their own practices. To fully exploit machine capability both the technicians and the designers should be able to conceptualise within this very specific 3D knitting environment.

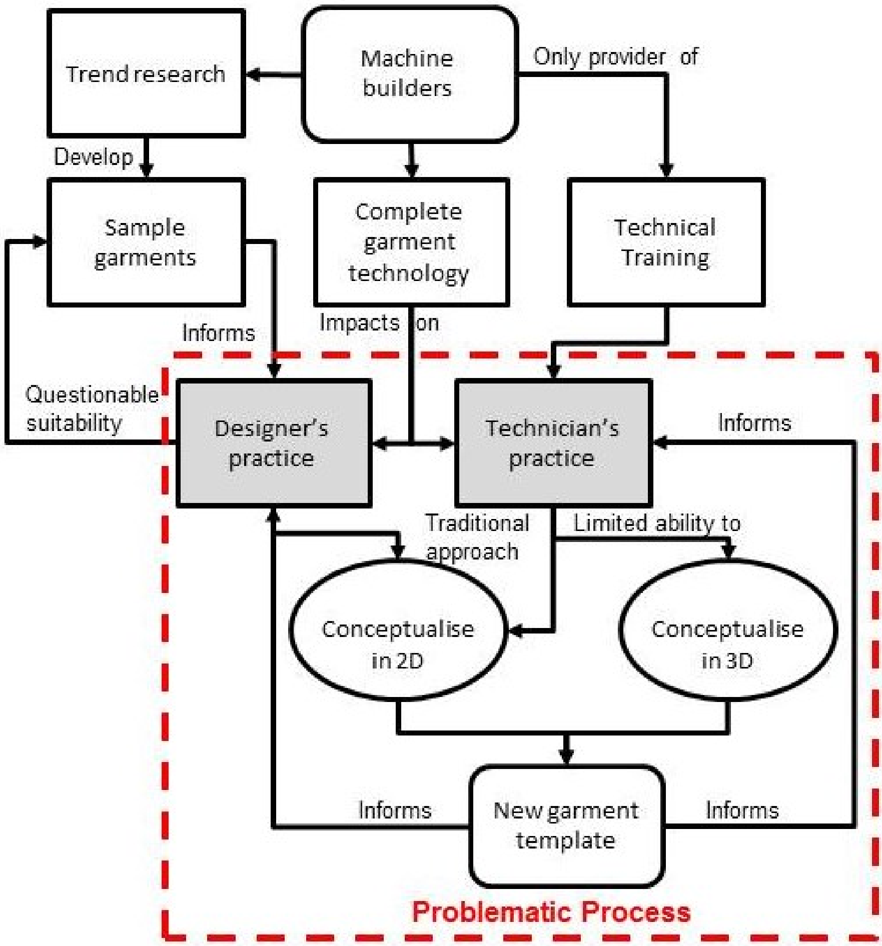


Figure 9.5 Influences on technical and design practice

9.4 Complete garment development: Innovation

There were numerous sources found within literature that claim complete garment technology has the capacity to innovate the knitted garment (Section 3.6 p55). Interviewees from the machine builders agreed with these claims. They were also aware of the investment being made by their employers to encourage innovation. Although case study analysis has led to the identification of a gap in knowledge and a lack of specific method (Sections 9.3.1 p240 & 9.3.2 p243), findings also demonstrate that many more garment styles were being produced than those shown in Table 3.1. (Sections 7.7.2 p167, 7.5.2 p143 & 7.3.2 p130). Styles that were evidently particularly suited to complete garment manufacture had been developed. Numerous garments were observed that provide good examples of innovation

(Sections 7.3 p130 & 7.5 p7.7 & 7.7 p166). In additional there was clear evidence that utilisation of complete garment technology enables flexible production methods and the potential to diversify into new market sectors (7.10 p186). The ability to customise, reduce waste and exploit new luxury fibres were also examples of increased capability which was a direct consequence of utilisation of the technology

Figure 9.6 illustrates the potential recognised by the case study interviewees, for complete garment manufacturers to develop new markets through specific product development. Opportunities for the UK knitters to create new business opportunities were perceived by the interviewees at KM1 to be reliant on investment in research and development. To be able to diversify into different market sectors, new marketing strategies are required.

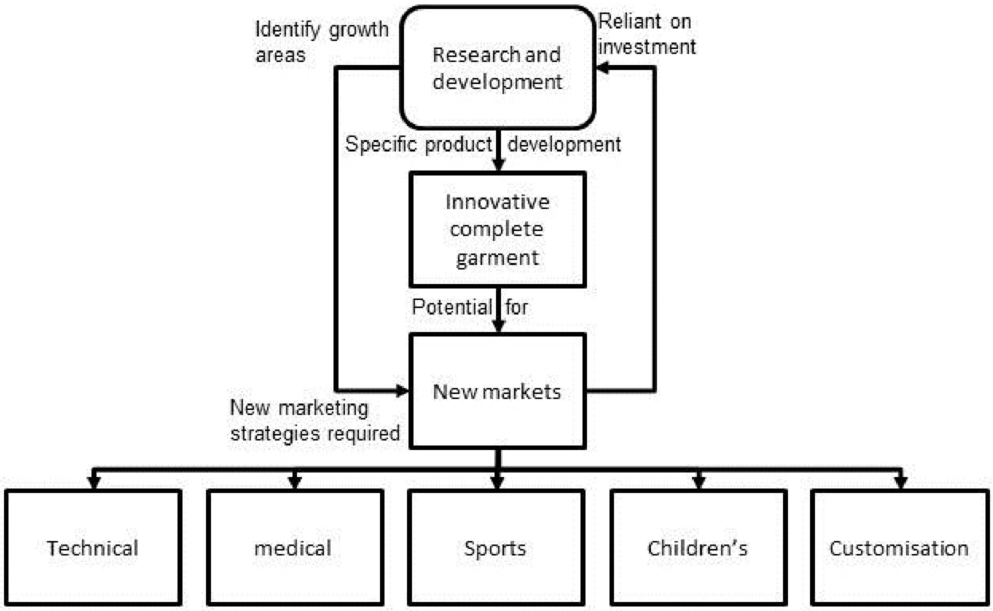


Figure 9.6 Potential to develop new market sectors

9.5 The 2D garment: fit improvements

Previous articles claim that advanced complete garment technology enables novel shaping that will help to improve garment fit (Karasuno 2000; Mowbray 2005a). Although Stoll claim that their complete garment technology is capable of creating garments that conform to the human body through utilisation the of sophisticated shaping methods (3.8.2 p62), the interview data from the machine builders did not relate shaping capability to improved garment fit (Section 6.4 p114). The case study analysis provides some indication that the application of novel shaping had influenced garment fit (Sections 7.4.2 p138 & 7.7.2 p167). However an evident skills gap within the product development teams will prevent any objective fit developments (Sections 9.3.1 p240 & 9.3.2 p243). Fit improvements were primarily regarded to be a consequence of the seamless structure of the complete garment. Not only was there evidence to indicate that seamless garments were perceived to fit a broader spectrum of body shapes and sizes, but at KM2 grading increments had been adjusted accordingly (Section 7.4.2 p138). No objective trials had been conducted to quantify the suggested change. Garment observations (Sections 7.2.2 p124, 7.5 p143 & 7.7 p166) also revealed that in lines with most traditional knitwear, the majority of the complete garments were two dimensional and rely solely on the extensibility of the knitted fabric to fit body curvature. There is clear evidence demonstrated by the theoretical framework for knitwear fit preferences (Section 8.12 p233) that female consumers are not always satisfied with extensible fit. The concept that additional extensibility creates improved fit is therefore very limiting. The consumer data analysis did however reveal the potential preference for seamless garments in relation to comfort and drape.

9.5.1 The process of fit evaluation

Case study analysis provided considerable evidence to show that fit trials were relied upon, to determine the relationship between the garment and the body. Fit evaluation has been acknowledged to be a complex process of assessment (Loker *et al.,* 2004; Borrogaard 2005; Chatteramann and Rudd 2006) which invariably relies heavily on subjective personal judgement (Section 2.7 p32). Provoked by this premise, studies have been conducted in order to bring some semblance of objectivity to fit evaluation practices. None of these however were knit specific and therefore are difficult to translate to the knitwear industry. For instance, Ashdown and O'Connell (2006) assessed fit using criteria that only relates to woven garments, such as straight grain and seam lines. No previous studies relating specifically to fit evaluation criteria for fully fashioned or complete garments have been found. Criteria to evaluate fabric properties in relation to fit were also acknowledged to be a requirement for knitwear (Watkins 2006). It was evident from interview analysis that an objective evaluation of fabric properties was not conducted within the product development process. Decisions are based on empirical knowledge accumulated through years of experience. The impact of garment extensibility on fit is therefore evaluated subjectively. Changes in knit structure can be used to create shaping for knitted garments (Guy 2001; Spencer 2001), however without an evaluation of fabric properties in relation to fit, exploitation of this method to create satisfactory fit is limited.

The case study data analysis provides evidence to show that fit evaluation for complete garments was a subjective process and no clear fit criteria were found.

Multiple fit trials were needed indicating that the product development process incorporates time consuming and costly iterative cycles of assessment, rejection and modification. It was also clear that achieving fit was less complex for manufacturers who had autonomy over the fit evaluation process. Additional problems were caused for the high street supplier because of inconsistent fit demands from different retailers (Section 7.2.7 p128). A system that more clearly identifies customer expectations regarding garment fit could help to reduce the number of samples produced before satisfaction is reached. Figure 9.7 identifies the lack of skills and knowledge that contribute to this iteration. It is the technicians who are relied upon to create the desired results and the model identifies this as significant. Inconsistencies between the size specifications provided by the individual retailers are an additional factor, found to be the cause of unnecessary and costly sample modifications.

Bye and Labat (2005) recognised that inconsistencies regarding the dimensions of the fit models used in industry fit trials to be problematic. Analysis of the case study data suggests that this situation is exacerbated within the knitwear industry because the extensibility of a knitted garment is perceived to justify the regular application of approximations within fit practices. Knitwear was expected to fit a variety of different shapes and sizes (Sections 7.4.7 p142, 7.2.8 p129 & 7.6.5 p165).

9.5.2 Satisfying consumer fit demands

3D body scanners have been used to generate body shape classification systems from population data (Simmonset al. 2004a; Simmons et al. 2004b; Lee et al 2006). These systems can be used to identify the most prevalent body shapes occurring within a population. These studies indicated that women's fit preferences were influenced by their body shape and that it is possible to predict these preferences if their body shape is known. This study has developed a theoretical framework for preferences specifically related to knitwear and provides insight into which garment characteristics female consumers prefer. Evidently the first priority for female consumers is to find garments that provide flattering fit. The theoretical framework also provides some basic guidelines to show how flattering fit can be achieved which involves informed selection of extensible fit and draped fit to emphasise and disguise specific regions of the body. This study reveals that consumers have complex fit demands and prefer knitwear that fulfils this complex set of fit demands.

Novel approaches such as these could help to inform complete garment design which acknowledges consumer fit satisfaction. Some UK knitwear manufacturers are evidently using at least three different body shapes within their template range, which it is hoped will satisfy a wider number of women. This approach related to a change in the type of fit, namely a loose draped fit, a slightly tighter fit, or a very close fit. A more informed approach would surely satisfy a wider number of women. This current business practice also demonstrates that it is considered commercially viable to develop garments for specific body shapes.

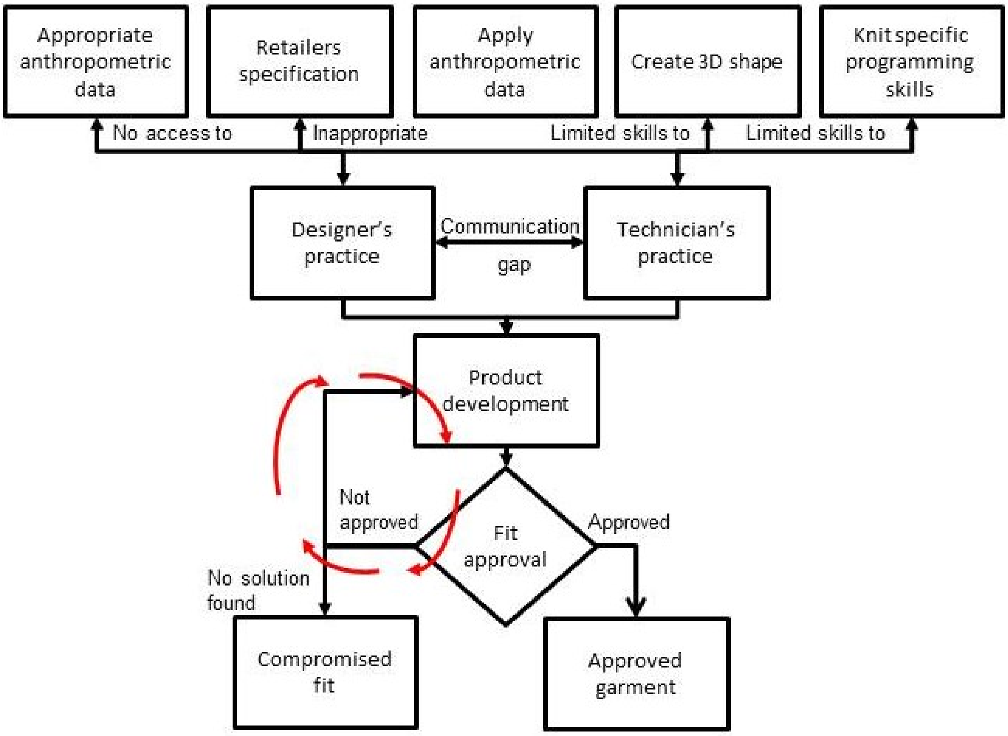


Figure 9.7 Iteration within the product development process

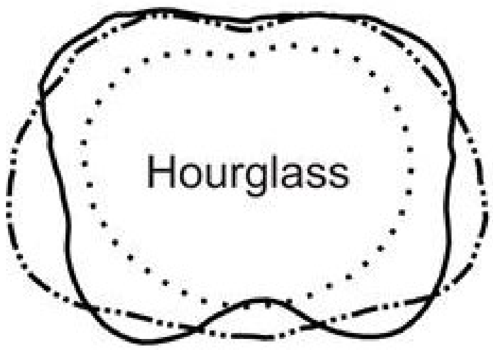
9.6 Shaping to create 3 dimensional garments

Despite all the indications that machine developments increase the potential to create 3D shaping (Black 2001; Guy 2001; Karasuno 2000), the case study analysis provides further evidence to show that as a consequence of traditional fully fashioned influences complete garments are primarily developed as 2D structures. The front and back of the garments conform to the same basic dimensions (Section 9.5 p248). Even some of the attempts to create 3D shaping were evidently informed by fully fashioned 2D conceptualisation (Section 7.5.2 p143) With specific reference to the body, there was no evidence from the garment observations to suggest shaping has been used to conform to the shape of the bust, the waist and the hips. Only one garment had shaping constructed to conform to the three dimensional curvature of the body (shoulder) (Table 7.7 p146).

Early accounts of complete garment knitting illustrated that the development of the complete garment must be conceptualised in relation to the needle beds, which are configured in two parallel lines (Brackenbury 1992). Data analysis from the case studies revealed that the technicians' rigid approach to the conceptualisation of the garment on the needle beds (Section 7.9.1 p183) perpetuated the tendency to develop 2D garments. Problem solving exercises demanding a different approach had been successful and demonstrate that new methods can facilitate improved results. It was however evidently problematic for the product development teams to break away from known practices as it involved time consuming experimentation.

9.6.1 Shaping: the potential for skills development

It has been acknowledged that a lack of technical education for knitwear designers undermines their ability to fully exploit machine capability (Guy 2001; Sayer 2006). This study not only conforms this to be true in relation to complete garment designers in the UK but identifies a skills gap regarding the application of anthropometric data to complete garment development. The process of knitted garment construction is frequently described through mathematical terms using technical terminology (Mills 1965; Walsh 1966; Raz 1993). Spencer's (2001) method for calculating the shape of a knitted panel is easily demonstrated visually and a limited number of sources provide guidance on how to manipulate fashion frequency to create patterns for knitted garments (Power 2008; Sissons 2010). These methods would not be appropriate for complete garment manufacture which is tubular and demands a 3D approach. Haffenden's (2010) study used the slice tool from a 3D body scanner to guide a new approach within the development of fully fashioned knitwear. Haffenden's (2010) methods were not published but for complete garments that are knitted as tubular structures a tool that can facilitate 3D conceptualisation of the body in addition to accurate body measurement would be highly suitable for use within complete garment development. To demonstrate this concept, Figure 9.8 (p253) shows slices of an hourglass figure, taken from a TC2 body scanner alongside a simplified representation of the complete garment on the needle beds. The body slice tool provides measurement data so it is possible access girth measurements and vertical measurements between each slice taken, a calculation to find the stitch density would provide the number of courses and wales needed to knit a tube to fit the body. Strategic application of integral shaping would shape the garment.



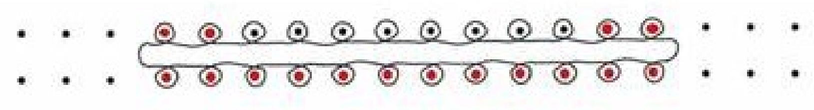


Figure 9.8 3D conceptualisation body scan slices and needle beds

A critical area of the garment has been shown to be the armhole and the sleeve head where the three tubes begin to combine and the designer must specify the armhole shaping. It is at this point where the ability to conceptualise the shaping process is most difficult. The shoulder region will also figure within these calculations. The designer and the technician have to grapple with a number of issues including:

a) Complete garments have all their component parts knitted simultaneously on two or four needle beds. The implication is that every needle operation (narrowing, widening, transfer) at a given location will impact on the configuration of all the loops on the needle bed.
b) The stitches from the tubular sleeves must be transferred to the tubular needles knitting the tubular body portion. Calculations must be made to ensure the specified results are achieved.
c) There must be an even number of loops on each needle bed
d) Even the most experienced personnel will initially only be able to draw on knowledge that is applicable to shaped knitted panels
e) Pattern cutting skills for complete garment development do not appear to be available
f) An objective methodology for exploiting the properties of the knitted fabric is not used.

Figure 9.9 illustrates the factors that relate to limitation in skills and knowledge and the ability to shape the complete garment.

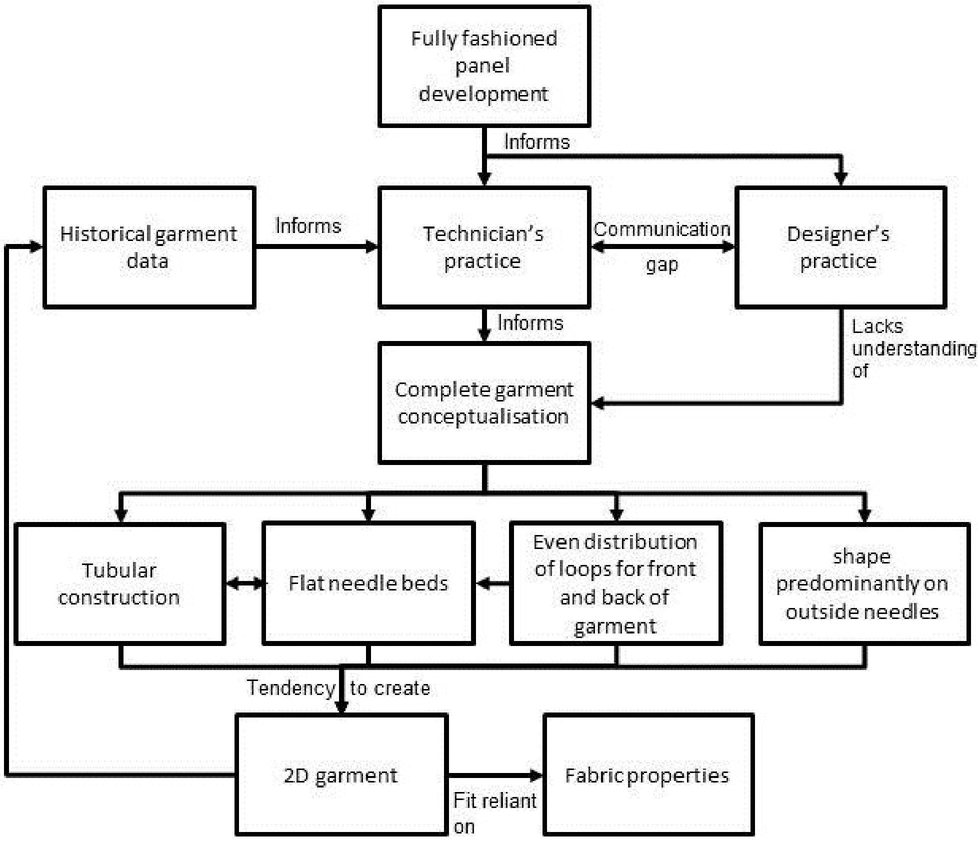


Figure 9.9 Identification of problem factors: shaping the complete garment

9.7 Sizing: utilisation of anthropometric data

The literature review provided evidence that satisfactory garment sizing is reliant on the utilisation of current and appropriate anthropometric data (Section 2.2 p21). There has been a drive towards better sizing systems. Large scale sizing surveys such as SizeUK show that retailers recognise the need for sizing improvement based on accurate data (Section 2.3.2 p23). Power (2008) identified a need for the development and use of standardised size charts specifically for knitwear. However based on evidence from this study, a considerable amount of initial research would be needed before standardised size charts for complete garments could be developed. This would include: identification of key dimensions that define the dimensions of the tubular garment, objective methods to evaluate the properties of knit structures and objective consumer fit trials to objectively evaluate whether grading practices need changing. To justify the utilisation of standardised size charts within the knitwear industry, UK retailers buying knitwear must consistent regarding their sizing demands. Case study data clearly shows that this is not an accurate reflection of the current situation (Section 7.2.7 p128).

Previous studies reveal that programmes provided by the machine builders are unlikely to provide support when aiming to improve garment fit through a more sophisticated 3D application of anthropometric data (Guy 2001; Haffenden 2009). This finding is substantiated by the case study analysis and further to this provides evidence to show that the automated grading facilities supplied with the technology were not used because they were found to be restrictive and unfit for purpose. Figure 9.10 illustrates the problems caused by the use of historical measurement and the application of empirical knowledge within the complete garment sizing processes. It demonstrates that there is an iterative cycle within the development of both prototype samples and graded garments. The reliance on historical garment dimension also creates a situation where the relationship between the body and the complete garment is not fully determined. Specifically the difference between the body measurement and garment measurement or the ease value is unknown.

Survey data such as that collected from SizeUK can provide insight into the size and shape of the UK female population at the time the data was collected (Bougourd *et al.,* 2000; Bodymetrics 2005). Unfortunately the information from SizeUK is only accessible at a price and although evidence was found to suggest members of the product development team recognised the need to be more informed about anthropometric, none of the case study companies had made an investment.

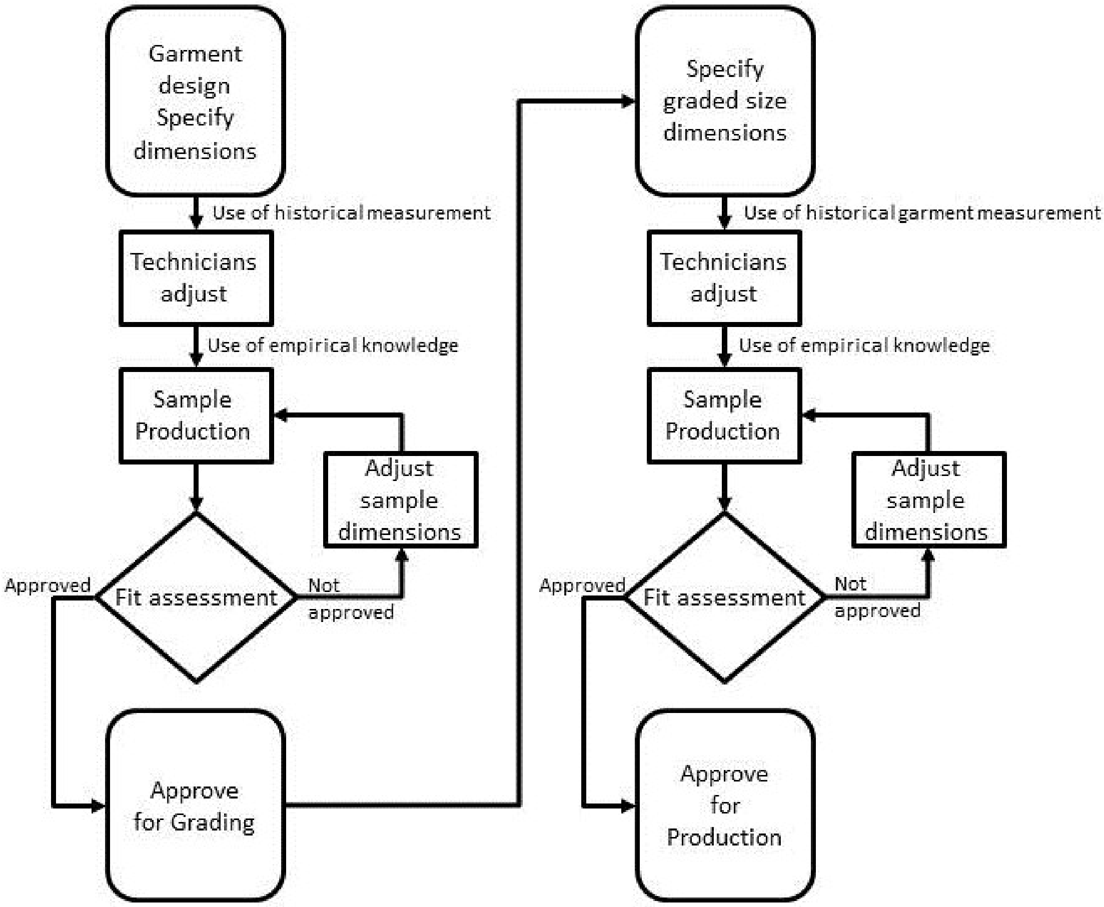


Figure 9.10 Iteration caused through imprecise methods

9.7.1 The impact of the technology on sizing

Mowbray (2002) indicated that complete garment technology could improve sizing consistency within knitwear manufacture and the interviews with machine builders provided some justification for this claim (Section 6.4 p114). Case study analysis however indicates that this issue was not widely acknowledged, although the digital stitch control was recognised to improve consistency of garment dimension by one technician.

9.8 The sizing process

The case study analysis provided clear evidence to show that because knitting complete garments involves producing the fabric and the garment simultaneously, size and fit practices must accommodate a high degree of unpredictability. This is particularly true if the garment is produced while the yarn is still in its raw state. Finishing processes all add an element of doubt regarding the impact on garment dimension. It was clearly accepted by the product development teams that the knitting process is inconsistent and precision difficult to achieve. This uncertainty encouraged practitioners to use trial and error and informed guesswork when sizing garments. In relation to design and development, it is not easy to explore the properties of the fabric in relation to the body before the garment is created. A designer of woven garments for instance is very likely to drape a fabric on a model or dress stand during the development process (Section 2.5.1 p28). Knitwear designers cannot easily make this connection and have to conceptualise the relationship between the body and the garment differently.

Power and Otieno's (2007) study focussed on sizing practices within UK knitwear manufacturers. Their investigation into size coding found a broad spectrum of different approaches and coding systems. The case study analysis conducted for this study provides evidence to show that all the case study manufacturers used different size coding (Section 7.11 p187). Consumers are clearly dissatisfied by the inconsistencies within coding practices (Section **Error! Reference source not found.** p**Error! Bookmark not defined.**) It is however only possible for manufacturers to be consistent within their own business, general inconsistencies in the market place are out of the individual suppliers control. The use of coding that consumers can clearly relate to is perhaps a more achievable option. Focus group data indicates that female consumers in the UK are most familiar with double numeric and descriptive size coding.

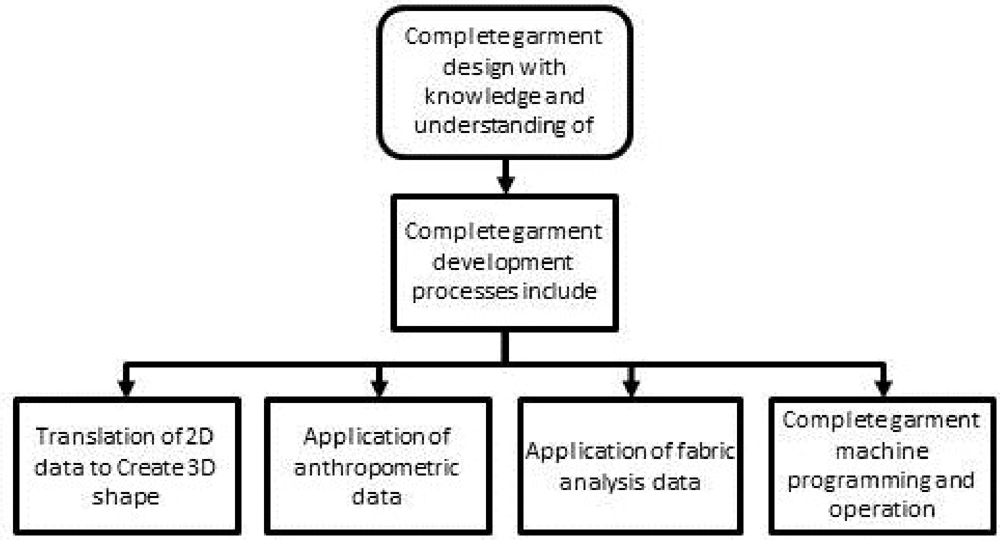
9.9 Development of the conceptual model

Throughout the discussion, a set of models have been developed to illustrate areas within the complete garment manufacturing process that have been found to be lacking. The development of the conceptual model for the utilisation of anthropometric practices, references these models and suggests potential new approaches within the product development cycle.

Figure 9.1 (p239) proposes that skills issues were found to be a primary deterrent to the implementation of complete garment technology in the UK. To utilise complete garment technology, manufacturers rely heavily on the machine builders for training and education purposes. Product development is therefore influenced by methods and shapes developed by the machine builders (Figure 9.5 p247). The knitwear designers, responsible for the initial conceptualisation of the garment, receive no formal training. They are expected to seamlessly transfer their skills and knowledge of designing shaped panelled garments to the complete garment development process. The technicians receive training from the machine builders. They are expected to realise the garment by transferring the 2D data provided by the designers into the 3D environment. Anthropometric data is not used and therefore neither the designers nor the technicians have the skills to relate 3D garment shape to the female body. Figure 9.2 p241 illustrates some of the repercussions of this lack of skills and knowledge.

To truly exploit 3D capability the model initially suggests the introduction of a new set of skills. Knowledge of the multidisciplinary processes should inform the development of the individual procedures within the product development cycle. Thus complete garment design, as the initial procedure within the development process should be performed with knowledge and understanding of machine operation, the application of anthropometric data and the creation of 3D garment shape. Designers should be aware of how to exploit the machine functions that create garment shape. To develop the garment without the use of pre-determined garment measurements, practitioners need to have knowledge and understanding of how to apply anthropometric data. To achieve satisfactory results, the relationship between body measurement and garment measurement should be transparent within the process. Knowledge of whether to add or subtract to body measurement in order to achieve the desired garment measurement and satisfy fit expectations is crucial.

The ability to create 3D garment shape within the parameters of complete garment machine capability is also a skill which is currently clearly lacking. In woven garment construction a good pattern cutter will have the skills to create complex 3D shapes from 2D fabric and apply anthropometric data in an appropriate manner for a range of differing fabric properties. This role was found to be absent in knitwear manufacture. The model therefore suggests that if complete garment technology is going to enable innovative knitwear design, methods of creating 3D garment shape, in relation to fabric properties, are considered. The first stage of the model development shows that these processes should be undertaken when developing complete garments. In addition knowledge and understanding of the identified



processes must inform the design of complete garments (Figure 9.11 p259).

Figure 9.11 Conceptual model development: stage one

Figure 9.9 p254 proposes that tradition shaping practices that predominantly conceptualise knitted garments as 2D structures influence the development of complete knitted garments. Although complete garment techniques create tubular structures, the need to utilise an even distribution of needles between the needle beds restricts the ability to differentiate when shaping the back and front of the garment. The conceptual model therefore suggests the need to consider using an uneven distribution of needles between the front and the back of the garment in order to provide the ability to create garments that relate to the female body. It is also necessary to consider all the active needles to create integral shaping through loop transfer, as is the need to conceptualise the garment as a shaped tube, not a flat back and front section. Improved garment fit will be realised if garments can be constructed through informed utilisation and application of anthropometric data and the ability to fully exploit machine capability as suggested. The second stage of the model development includes these technical issues (Figure 9.12).

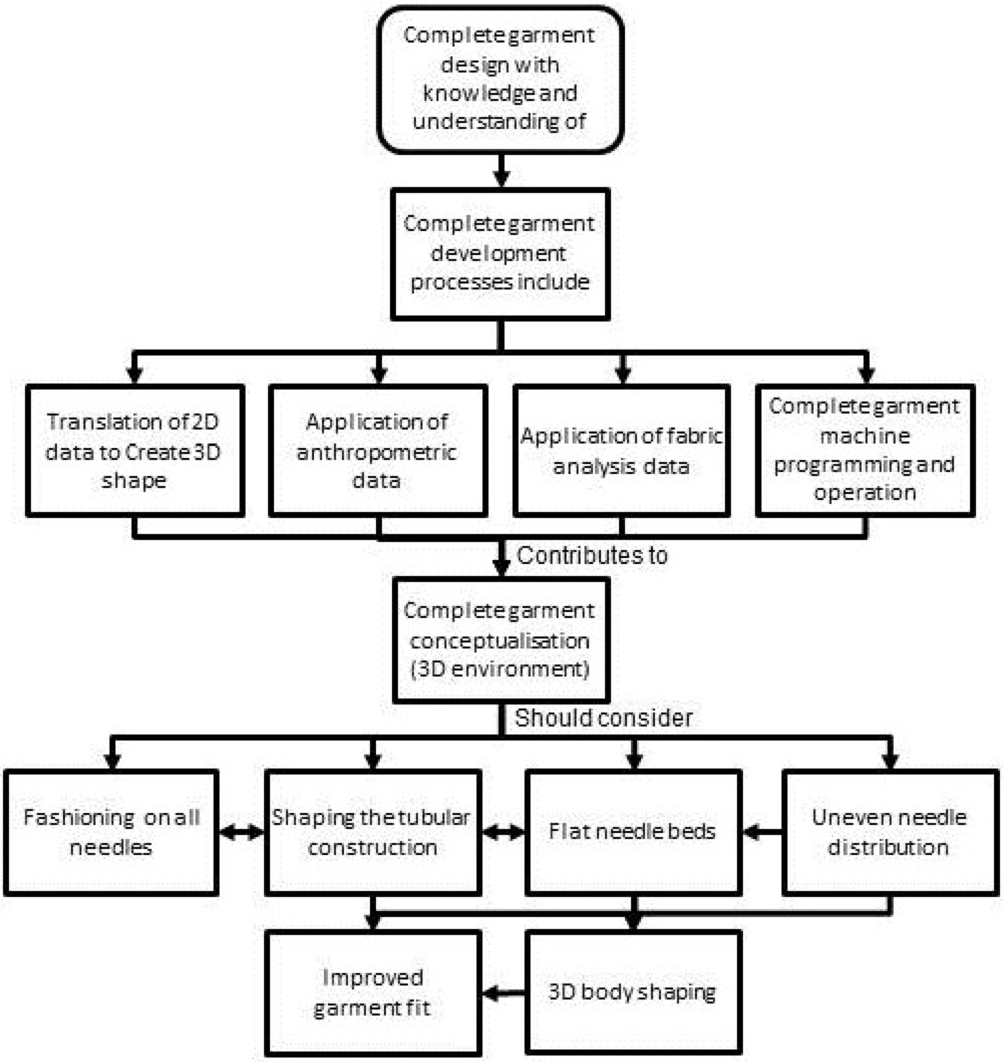


Figure 9.12 Conceptual model development: stage 2

The appropriate utilisation of anthropometric data would also contribute to the prevention of iteration within the product development cycle (Figure 9.10 p256). Currently however knitwear manufacturers do not work with anthropometric data and therefore the model suggests that further research needs to be conducted in order to generate data specific to complete garment manufacture. To develop appropriate size charts for use within complete garment manufacture the data must relate to the end consumer. Survey data from a representative sample is therefore needed to establish appropriate grading practices. Good size chart development relies on pre-determination of key body dimensions that are most relevant for the specific method of garment construction. To establish key dimensions for complete garment technology the analysis must incorporate knowledge and understanding of the complete garment construction processes. Cross sectional analysis of body scan data would relate well to tubular garment construction and could contribute to the identification of specific key dimensions. The third stage of the model development illustrates how the appropriate anthropometric data can inform the garment development process (Figure 9.13).

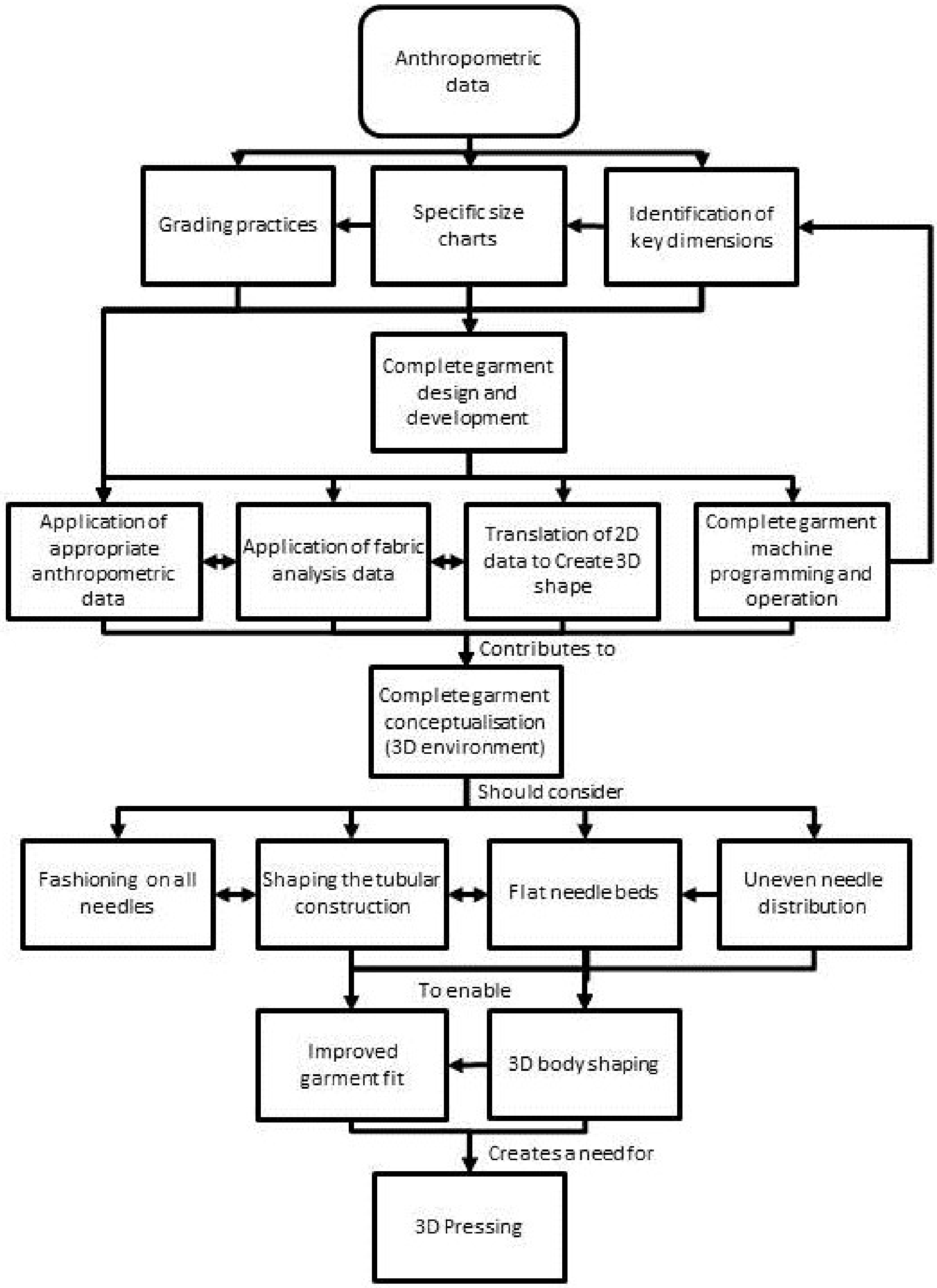


Figure 9.13 Conceptual model development: Stage 3

The fourth stage of the model development process considers consumer preferences in relation to knitwear and identifies new relationships accordingly (Figure 9.14 p264). With regards to sizing preferences, grading practices within knitwear manufacturers need to be consistent. Female consumers also prefer size coding that remains consistent and meaningful. The use of appropriate anthropometric data within the development process would enable manufacturers to accurately inform their consumers of the relationship between the garment dimension and the intended body dimension.

Body shape classification can be conducted using data from 3D body scanners and prevalence of particular body shapes within a population identified. This information would help designers to develop garments that meet specific consumer demands by applying the knitwear fit theories (Figure 8.2 p234). This would enable the development of garments that emphasise and disguise specific body regions to flatter specific body shapes. A good understanding of body shape would also contribute to the development of skills to conceptualise the garment as a 3D structure that relates to the body. The exploitation of complete garment technology to create garments that can conform to specific fit preferences and thus improve fit would provide opportunities for new niche markets (Figure 9.14), not just for fashion or luxury garments. The sports, technical and medical sector have all been shown to be market sectors which offer potential business opportunities.

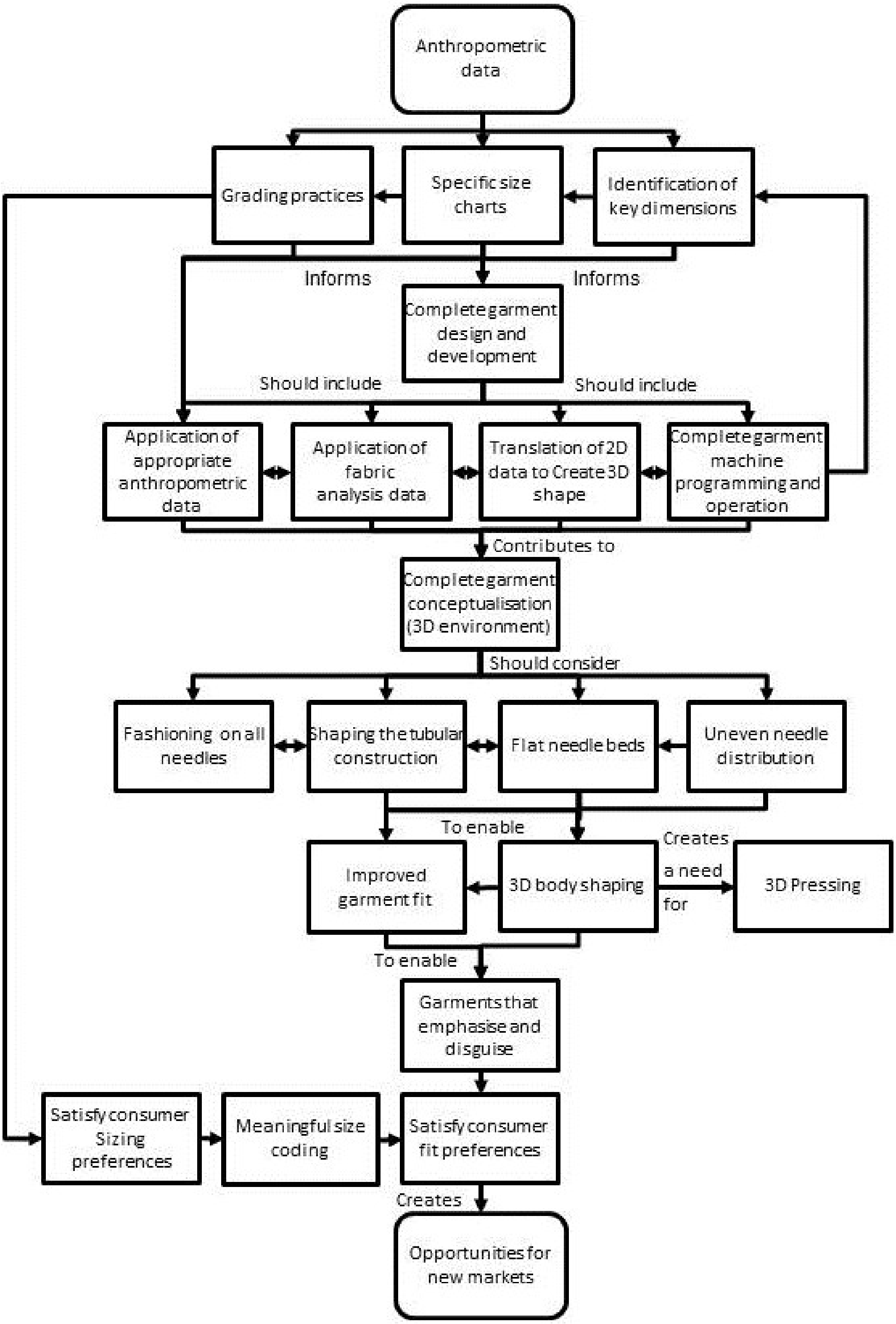


Figure 9.14 Conceptual model for anthropometric practices

Chapter 10 Conclusions

10.1 Utilisation of complete garment technology

Although previous studies have been conducted into anthropometric data within clothing, this study is the first to specifically focus on the complete knitted garment in relation to the utilisation of anthropometric data within the UK knitwear industry. As complete garment technology has only been commercially available since 1995, the initial phase evaluated the extent to which UK manufacturers were utilising the technology. It provides clear evidence to show the machine builders, drawing on their experiences within the industry were very firmly of the opinion that the UK knitwear industry was in decline and therefore not a potentially lucrative market. The fact that only 5% of the original sampling frame of 128 UK knitwear companies had implemented the technology supports this view and also proposes that manufacturers under threat from cheap imports were seeking investment that provides transparent opportunities to reduce production costs. Complete garment technology was found to be costly to implement and did not reduce knit times. The machine builders were very cautious about over stating its benefits in terms of cost and productivity.

In addition to cost issues, case study analysis from three UK manufacturers who had implemented complete garment technology confirmed that an exceedingly high level of technical skills were needed in order to utilise complete garment technology. This finding concurs with predictions that skills issues would inhibit knitwear manufacturers from investing in the technology. Further evidence from the case studies demonstrates that it is not only technical skills issues that potential investors must consider. Utilisation was found to increase communication problems that were known to already exist (Eckert 2001) between knitwear technicians and designers. This was because specific complete garment training is only provided for the technicians and not the designers. The need to train knitwear designers was not acknowledged by either the machine builders or by those managing the product development within the knitwear manufactures. This study proposes that educating the designer is a significant factor that should not be ignored if the benefits of utilisation are to be realised.

The case study analysis also provided very clear evidence to show that fully fashioned knitwear manufacturers in the UK cannot maintain the necessary levels of skilled labour within their post-production facilities. This is a further threat to the high end luxury market that has been identified as a sector of the UK clothing industry with the potential to survive the threat of cheap imports (Mintel 2008). Complete garment technology does provide real solutions to this problem and was the primary reason why all the case study companies had invested. This study provides additional evidence to suggest that it was the case study companies producing the quality and luxury knitwear who were most able to exploit the benefits of complete garment technology. The manufacturer supplying UK high street retailers were less able to influence design decisions and invest time in experimental development. It was also clearly evident that the UK retailers were largely unaware and unconcerned about the potential of this unique product. Supplying to a high street that demands fast fashion and quick response evidently did not provide an environment where innovative design could flourish.

1) **To analyse the utilisation of complete garment technology related to garment fit in the UK knitwear industries and the implied impact on product development.**

An analysis of the impact that utilisation of complete garment technology has on product development revealed that processes were overly dependent on pre-established garment templates and highly valued technical skills. The manufacture of a garment that had a 3D structure meant that templates and information from traditional fully fashioned knitwear were no longer relevant. However the only source of specific complete garment support and information were the machine builders. This created a situation where either outmoded methods, templates and information were being applied within the 3D environment, or manufacturers rely on the machine builder to supply the relevant information. This study provides evidence to show that this situation limited design autonomy. The findings from this study assert that the development of skills and knowledge within the product development teams should be a priority. Implementation had also clearly had an impact on the relationships within the product development teams. It was apparent that the technicians had gained a higher level of autonomy as they had received all the training. The designers had less knowledge of the technical processes and therefore less ability to influence development decisions.

Throughout this study, the critical review of literature, the interviews with the machine builders and the case study analysis, the evidence indicated that knitwear is not traditionally constructed with suppression to create a 3D structure that conforms to body curvature. It is not deemed necessary to take such an approach as the properties of the knitted fabric enable the garment to stretch and mould to body curvature and generally, flat 2D garments are thought to adequately conform within fit parameters. It was also evident that within the traditional fully fashioned industry, garment panels are shaped or fashioned at the edges of the panels which only shapes two dimensionally. 3D, integral shaping is not generally considered.

The analysis of the utilisation of complete garment technology related to garment fit revealed that the seamless structure of the complete garment had been recognised to provide increased extensibility. This novel characteristic was evidently viewed by the machine builders and some of the case study participants to represent fit improvement. Data analysis showed that these claims were subjective and anecdotal and were not based on an evaluation of the relationship between the garment and the body. The idea that increased extensibility will generate fit improvements propounds the traditional view that fit is reliant on the properties of the knitted fabric. Analysis from the focus group data provides evidence that confirms that many women are not satisfied with garments that closely conform and mould to their bodies. The notion that additional extensibility provides improved fit would therefore be rejected. It is subsequently proposed that increased extensibility of the seamless complete garment does not represent improved garment fit.

There was very little evidence from the case study analysis to indicate that new shaping capabilities to specifically improve fit had been utilised and the majority of the garments conformed to a traditional 2D structure. However, analysis from garment observations did clearly show that the potential to exploit the 3D tubular structure of complete garments and the shaping capabilities could provide many opportunities for informed practitioners to improve fit. A key finding of this study was that traditionally, within the knitwear product development process there are not opportunities to relate to the body or utilise anthropometric data. It was also evident from the interview analysis that practitioners, technicians and designers, did not have the skills to relate fit demands to the appropriate shaping methods. There was evidence of a very real lack of knowledge and understanding of basic principles needed to create fit. Additional evidence to support the notion that knitwear is traditionally conceptualised as a flat 2D structure was the use of pressing equipment that can only press the garment flat. It has been clearly demonstrated that the 3D structure of a garment is damaged when the garment is pressed flat. It was evident that the knitwear industry needs to embrace a new approach to garment manufacture within all the manufacturing processes.

The seamless characteristic of complete garments was also recognised by the machine builders to provide additional comfort, particularly relevant for garments worn next to the skin. The focus group analysis revealed that consumers could easily recognise seamless comfort as a benefit, however it was evident that the UK manufacturers were not exploiting this potential benefit either by focussing on specific product development or within their marketing. They were restricted by a lack of investment for research and development. Another key finding from this study relates to the paradoxical situation that UK manufacturers find themselves in. Threatened by cheap imports and industry decline it is risky to adopt strategies to invest in costly research and development projects that explore the potential of new products. However it is also risky not to explore potential new markets and remain static when the current industry is under threat.

Aim 3

The evaluation of the utilisation of anthropometric data within the complete garment development process established that appropriate anthropometric data or size charts were not currently unavailable to complete garment manufacturers. It was evident from the literature, the machine builders and case study analysis that anthropometric data has not traditionally been used within the development of fully fashioned knitwear. Instead pre-established garment measurement is used. If the majority of the garment development is merely to make modifications such as changing necklines, garment lengths and size, this approach may be adequate. It was however evident from the case studies that trying to convert the data from fully fashioned panelled garments to the tubular structure of complete garments was not appropriate. In addition, case study findings indicate that those working in the UK complete garment knitwear industry are not experienced or knowledgeable in the application of anthropometric data to create 3D garment shapes that relate to the body. It was in fact evident that there was a clear lack of knowledge regarding the construction of a three dimension garment shape.

Traditionally a knitted garment relies on the ability of the knitted fabric to stretch and mould itself around the body to achieve satisfactory fit. Unlike pattern cutters working with woven fabrics who understand how to create complex garment shapes that fit and flatter the body, the case study data revealed that knitwear practitioners do not develop these types of skills. The knitwear designers were primarily concerned with trend research, and developing ideas for knit structures. They were concerned with creating garment silhouettes to create fashionable shapes, but had very little technical knowledge in relation to creating 3D garment shapes. Design concepts were therefore often compromised due to what was perceived to be machine limitation. The technicians' skills were found to be deeply embedded in the fully fashioned tradition. They are responsible for creating garment shape within the tubular structure of the knitted garment. They were therefore expected to create 3D shapes that relate to the female body without a framework or methodology to guide the application of anthropometric data. Data analysis has demonstrated that shaping limitations were not purely an issue of mechanics but relate to both a skills gap and a lack of appropriate methodologies to create shapes that relate to the body. Without technical knowledge, the designers cannot focus on how to exploit the potential of complete garment technology to create novel garment shaping and improve fit. Within the product development team the knitwear technicians was the primary influencer on garment fit. However it is not traditional for the technicians to attend fit trials and were therefore less likely to develop understanding of how their shaping practices influenced fit.

Examples of compromises being forced by the lack of technical skills and understanding of how to create a 3D shape that fits the body were also found. Fit problems identified during fit trials had not been solved and the data indicates that the ability to change the shape of a sleeve in an armhole was not present.

Evidence from both literature and the case studies indicate that it is knitwear designers who specify the required garment dimension. These dimensions were invariably found to be based on previous garments. There was no evidence, either from literature or from primary data to suggest that calculations are made to translate body measurement into relevant garment dimension. The case study manufacturers did not employ a practitioner skilled in creating garment shapes that relate to the body, a role fulfilled by a pattern cutter in woven garment manufacturing. If the pattern making process is perceived as the planning process which translates 2D information to 3D information, then it is this planning process which appears to be absent or lacking within the product development process for knitted garments. This missing step in the process has profound implications when new technologies force changes to traditional working practices. Knitwear designers are therefore performing a task for which they have no expertise. Nor is there literature to inform designers on relevant methods to apply anthropometric measurement to knitwear. It is therefore understandable that all the case study companies relied on historical garment measurement data during product development. This reliance must however limit creative product development and the generation new garment styles. The case study data supports this view point, revealing that garment innovation had only been achieved through a slow process of trial and error and had in some cases been detrimental to production efficiencies.

10.1.1 Estimation and informed guesswork

At KM1 there was a great degree of informed guesswork used to determine garment dimension. The extensible nature of knitted fabric is thought to conceal any small irregularities.

The knitwear industry is only equipped to produce flat garments. Tools for pressing for instance are constructed for flat shapes. A garment that does not conform to the norm therefore presents a whole set of novel problems.

Develop a really clear example of how garments could be developed using anthropometric measurement. Calculate the fashioning using Spencer. Look up the machine developments and what they might actually imply in terms of the ability to shape and construct. Use diagrams and scan data (body segments). If a system that related anthropometric data, properties of differing knit structures and machine capability was developed, designers would be able to create garment shapes without using pre-established measurements. Currently there is some knowledge missing.

Show how the

[Design and fit requirements were at times perceived to be unachievable case study fit].

4) To develop a theoretical framework for preferences of UK female consumers relating to size, fit and shaping of knitwear.

The investigation into consumer preferences relating specifically to knitwear is a new field of research. As a result, the development of appropriate methodologies to solicit data was challenging and involved a degree of trial and error. Data analysis from an initial questionnaire revealed that some female consumers were alienated from the technical aspects of clothing and therefore could not differentiate between knitted and woven garments. This disassociation was an aspect of consumer clothing research that impacted on how data was solicited and is useful to inform subsequent studies. Data analysis from exploratory focus group investigation provided further insight into female consumer perceptions of knitwear and found a close association with notions of unflattering, bulky garments and outmoded dress. Without recognition of this association, the subsequent analysis of preferences would have been prejudiced through miscommunication of the idea of knitwear.

The data analysis initially focussed on how female consumers evaluated knitted garments in relation to satisfaction. No previous studies have focussed specifically on knitted garment characteristics that influence satisfaction. This study therefore provides additional insight that will inform the product development processes. The key garment characteristics identified were; Flattering fit, comfort, warmth, shaping aesthetics, colour, and a negative influence was identified as additional bulk.

The focus groups provided opportunities to analyse data qualitatively from open discussion which revealed just how intensely female consumers focus on their bodies when discussing fit. There was overwhelming evidence to show that female consumers within the selected demographic are primarily seeking garments that flatter their bodies. As this notion of flattery was so central to the provision of fit satisfaction, further data analysis explored how the consumers determined fit flattery. This analysis once again centred around the body with the majority of the women criticising specific body regions. Garments were selected to conceal these unsatisfactory body regions. This is not a new idea and has been explored in previous studies. This study relates the notion of concealment and disguise to knitwear and reveals that the consumers generally related extensible knitted garments to the idea of being exposed. Knitted garments did not fulfil their need for concealment or disguise. However it is too simplistic to simply state that women who are dissatisfied with their bodies avoid knitted garments that make them feel exposed, as the analysis also provided clear evidence to show that women not only recognised the draping quality of knitwear but they registered a preferences for this type of fit but again only at strategic regions of the body. Garments that were too loose were considered unflattering because they increased body size. The theoretical framework evaluates the key aspects of these fit preferences and proposes that female consumers prefer knitted garments that provide an extensible fit over body regions that cause satisfaction. A draped fit is preferred over body regions that cause dissatisfaction. This analysis reveals that to satisfy consumers fit demands it is not just a matter of providing garments with a tighter or looser fit, but the extensibility and draping qualities of a knitted fabric should be exploited within one garment, to shape that garment strategically around the wearers body. If this is theory is taken as a basic premise within the development of complete garments, it would encourage designers to explore new methods to create flattering shapes for the female body.

Focus group exploration also provides insight into how female knitwear consumers perceived sizing. The analysis showed that consumers over a size 14 were dissatisfied with sizing but those size 14 and under were generally more satisfied. The open discussion about sizing provoked many comments negative comments about body dissatisfaction, revealing a very clear relationship between sizing dissatisfaction and body dissatisfaction.

5) To develop an original conceptual model regarding the utilisation of anthropometric data related to complete garment technology for the UK women's knitwear industry.

[The designer will be prioritising the creation of the knit structures, not necessarily looking at how to create a garment for the female body. Think about how this data compares with the data from the focus group where the women were all so aware of their bodies when buying clothes]

In terms of using clothing to create shape and structure for the body, woven fabrics that can hold their shapes will always be able to perform in a more satisfactory manner. Knitted fabric will always have a tendency to drape and mould. If for instance a designer wishes to create a shoulder line that stands away from the body (on women this) knitted fabrics are less likely to be able to fulfill this objective and more likely to conform to a much more natural body shape.

Complete garment technology can create integral gathers. In the hands of an informed and creative design team this capability could be exploited in many ways to create novel garment shapes. These opportunities are lost unless designers a) develop the necessary skills and knowledge b) have the time for research and development.

This study has made an evaluation of industry practices and the utilisation of anthropometric data, particularly in relation to size, fit and shaping of garments knitted on complete garment technology. A number of issues relating to the utilisation of anthropometric data and knitwear fit preferences have been identified and discussed in 0. In addition the study has generated two research outcomes: A theoretical framework for female knit preferences (Section 8.12, p233) and a conceptual model regarding the utilisation of anthropometric data for the UK women's knitwear industry (Figure 9.14, p264).

10.2 Recommendations

New methods of anthropometric data procurement specifically designed for the application to complete knitted garments would be of benefit. Use of body scanners and the slice tool. Further research to quantify draped or loose fit and extensible fit. What are the parameters? How can they be established?

- Methods relating to the application of anthropometric data to complete garment development.
- Methods to create three dimensional garment shaping that comply with consumer fit demands.
- the appropriate anthropometric data to apply to the process of complete garment development.
- appropriate methods to press complete garments that are shaped three dimensionally.
- It is possible to develop complete garments that conform tightly to some body regions and loosely to other body regions.
- Garment fit is a very high priority for female consumers
- A primary defining factor of the concept of fit is the provision of body shape improvement
- Two primary defining aspects regarding the concept of body shape improvement is the ability to disguise and accentuate specific body regions.
- Knitted garments were perceived to accentuate the body.
- Female consumers are selective about which region of the body they prefer a knitted garment to conform to.
- Generally female consumer's perceptions of knitwear can be negative and connotes an unflattering garment belonging to a bygone generation.

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Appendix A Knitted loop formation

Those that have been found to affect the dimensions of the fabric are listed below:

A missed stitch refers to a technique of allowing one needle to retain its loop longer than the other needles in the needle bed. (Figure 0.1). Missed stitches will create greater stability in the knitted structure as one stitch connects two adjacent wales reducing extensibility.

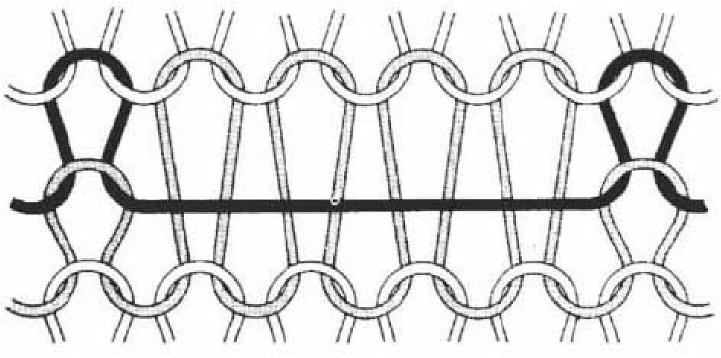

Figure 0.1 Loop formation: missed stitch

(Adapted from Kothari 2010)

A tuck stitch refers to a technique of tucking the yarn into the knitted structure instead of forming a loop (Figure 0.2). The resulting stretched elongated loop shrinks when relaxed and forms a buckle in the fabric. This technique creates added width thickness and weight to the fabric.

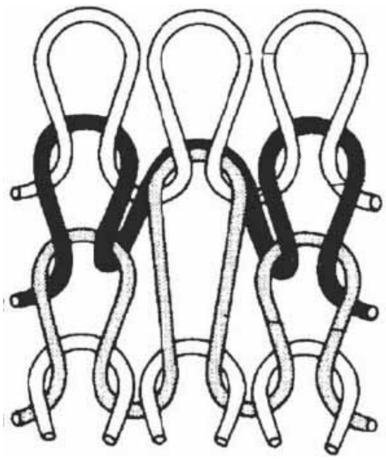

Figure 0.2 Loop formation: tuck stitch

(Adapted from Kothari 2010)

In addition to the different stitch types transfers can occur. A transferred stitch refers to a technique where loops are transferred from one needle to another. This could be between two needles in the same bed (plain knit transfer stitch) or between two needles on separate needle beds (Rib loop transfer stitch) (Figure 0.3) This enables a flat machine to produce shaped fabrics (Section 3.4)

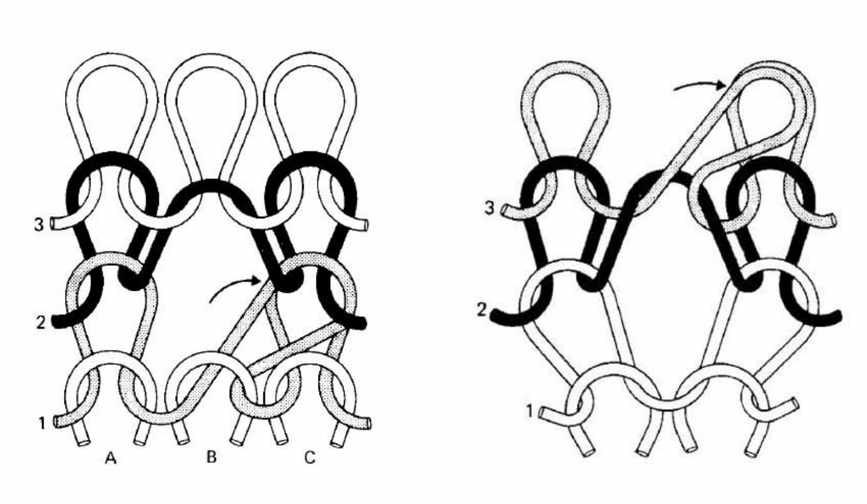

Figure 0.3 Plain knit transfer stitch (left) and rib loop transfer stitch (right)

(Adapted from Spencer 2001)

Appendix A.1 Knitting notation

To indicate how the knitted loops are configured on the needle beds a simple set of diagrams are used. The figure that shows the loops on the needle provide a good graphic representation and help to explain the parameters that those working within the industry must acknowledge when developing garments. The noughts and crosses grid helps when visualising the creation of a knit structure.

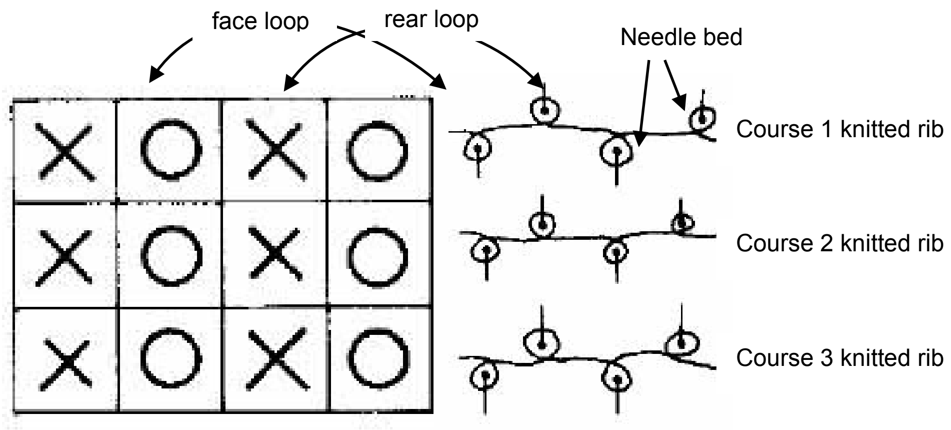

Figure 0.4 Knitting notation (Adapted from Spencer 2001)

Appendix B Complete garment press speculation

Shaping capability

The machine shaping capability has a direct impact on both the design innovation (Section 3.6.3) and improved fit (Section 3.8.2). Reports that acknowledge the shaping improvements frequently relate them back to specific machine improvements. Shima Seiki's novel four needle bed configuration, for instance would speculatively provide a plethora of shaping possibilities (Gibbons 1995 Mowbray 2000). Karasuno (2000) is the first to state the possibility of three dimensional shaping. Other comments merely state that complete garment technology provides much improved shaping capability (Millington 2000; Hunter 2004b; Mowbray 2006c). Troynikov (2008) found more shaping limitations than possibilities, when attempting to develop a sophisticated fit for male and female sports garments. Regions causing most dissatisfaction were the shoulder, armhole and the sleeve head. These limitations were said to be caused by the limited number of needles that are able to transfer the sleeve head to the armhole at any one time. Troynikov (2008) is however making comparisons with cut and sew shaping techniques, not shaping methods used for knitted panels.

Quick response and Just-in-time

A number of articles suggest that the dramatic machine innovations on complete garment technology would enable the supply of a growing market demand for rapid response. (Millington1995; Gibbons 1995; Gibbons 1995b) (Gibbons 1995) (1995) (Gibbon 1995b). (Nakashima and Karasuno 1995; Nakashima and Karasuno 1996) (Spencer 1996) (Spencer 1999), (Shima 2000), Millington 2000; Mowbray 2006c. The ability to operate a just-in-time system of production, where stock levels are kept to a minimum, is also identified as a major benefit for the user of complete garment technology (Gibbons 1995a). (Stoll 2000), Millington 2000). These claims however remain unexplained and it is left to the reader to speculate on how quick response and Just-in-time systems of operation will be achieved through the utilisation of complete garment technology.

Labour: cost reductions and alleviation of shortages

The impetus for Shima Seiki to develop machines with complete garment capability was stated to provide manufacturers with the ability to increase productivity by reducing labour costs. This was identified as particularly important for manufacturers in high labour cost countries (Nakashima and Karasuno 1995; Nakashima and Karasuno 1996). Other authors have since emphasised the importance of this benefit (Gibbon 1997c) (Stoll 2000), (Shima 2000), (Millington 2000) Mowbray 2006c. More recently the emphasis has been placed on the ability of complete garment manufacture to alleviate labour shortages rather than decrease costs through labour cuts (Siddons 2007).

Flexible production

The capability to produce small production runs was also listed as a benefit, in particular for small producers (Nakashima and Karasuno 1995; Nakashima and Karasuno 1996). (Mowbray 2000) Mowbray 2002 Tait 2008. Small production runs were also identified as a benefit for producers wanting to supply the growing demand for fast fashion (Shima 2000)(Stoll 2000). Stoll's Knit and Wear machinery was praised for marrying complete garment capability with the abilility to knit fabric and fully fashioned garments. Flexibility regarding end use is perceived to be key to competitive advantage. At the time of writing Stoll were not claiming capacity to commercially produce complete garments.(Gibbon 1997a),

Comfort & Aesthetics

The seamless structure of a complete garment was cited as the cause for improved comfort and garment aesthetics by a number of authors. No depth of analysis was provided in relation to these benefits.(Spencer 1996; Gibbons 1997b; Shima 2000; Millington 2000; Mowbray 2002)

Reduction of yarn consumption & waste elimination

Nakashima and Karasuno (1996) made an early appeal to the ethical consumer, claiming that utilisation of complete garment technology reduces yarn consumption. Other authors have since noted this benefit (Stoll 2000; Millington 2000; Mowbray 2002). The terms waste elimination and waste free are also used (Shima 2000; Siddons 2007)

Customisation

Claims have been made that made to measure and customisation services are possible through the utilisation of complete garment technology (Kurasano 2000).

Sizing consistency

Although only reference has been found that refers to the potential for complete garment machinery to improve sizing consistency, it bears particular relevance to the aim of this research project and therefore is included. No explanation about how sizing consistency might be improved was made (Mowbray 2002).

Marketing strategies

The list of machine benefits perhaps are indicative of how the machine builders were marketing their products. There was certainly a retreat away from the emphasis of cost and labour reduction and a move towards extolling the ability to create new fashion and innovative garment styles (Mowbray 2002 p22). Reviewing the literature over this ten year period provides a clear depiction of Shima Seiki's urgent pursuit to persuade knitters that their WholeGarment® technology can create innovation in design, in addition to other more obvious benefits such as labour reduction. A feature on new developments in Stoll Knit and Wear machinery shows that it is still the labour saving, efficiency and short lead times that are the priority when listing the advantages of complete garment technology. (Mowbray 2006c).

Complete garment technology: Potential disadvantages

This focusses on the reported benefits knitwear manufacturers have experienced through the utilisation of complete garment technology. This section will review data relating to potential disadvantages or difficulties that may prevent manufacturers from investing in complete garment technology.

Skills and knowledge

Experts have questioned whether the skills and knowledge to exploit the capability of complete garment technology are present in the workforce (Brackenbury 1992; Black 2001; Mowbray 2003a Sayer et al. 2006). Troynikov (2008) reports difficulties when attempting to achieve shaping specifications and identifies a lack of patterns and data as a potential cause. Dr Shima, chairman of Shima Seiki admitted that inexperience within the industry had slowed the development of complete garment manufacture (Mowbray 2005a). Siddons (2007) suggests that complete garment design should be approached through programmers, implying that companies should employ designers with programming skills. However it is unknown whether there are any people with a mixture of what are traditionally two different set of skills (Eckert 2001) within the workforce. In order to advance the knowledge and skills relating to the utilisation of complete garment technology both Stoll and Shima Seiki produce concept garments (Mowbray 2002b; Mowbray 2002a). The Stoll website has a facility to download garment patterns (Stoll 2006). Shima are reported to develop over 2500 garments every year in order to demonstrate the capabilities of the technology (Mowbray 2005a). It has been suggested that the manufacturer's drive to create data for specific garments actually limits the potential for designers to experiment for themselves. It is therefore necessary to educate knitwear practitioners to be able to develop new products from an informed perspective, rather than take pre-established data from an un-informed perspective (Guy 2001; Sayer et al 2006). These comments suggest that the machine manufacturers are reluctant to release too much information. The practice adopted by the knitting industry to patent new garment development indicates that information is considered as a commercial asset. This presents a paradoxical situation; the machine builders, anxious to promote investment, feel the need to develop methods to enable investors to exploit their technologies, whilst striving to maintain ownership of commercially sensitive data that would inform independent development. To create a valid market for the technology, the consumer of the technology must be educated in order to successfully utilise it, but not to the extent that the machine builders' control of the information is lost.

Cost

Concern has been shown regarding the cost to both Italian and UK knitwear manufacturers who wish to implement complete garment technology (Mowbray 2003a; Mowbray 2003c). Although the technology may provide many benefits these must be balanced against the cost of implementation. For knitwear manufacturers in a deflated market the risk may be too great. In addition an Italian source claims that complete garments themselves were actually more costly than other types of knitwear (Mowbray 2003a).

Appendix B.1 Summary of the potential benefits of complete garment technology 1995-2000

Benefit identified	1995	1996	1997	1998	1999	2000
Innovate design	Nakashima and Karasuno Spencer Gibbons	Nakashima and Karasuno Spencer	Gibbons	Millington	Mowbray	Stoll Karasuno Karasuno
Improve fit		Nakashima and Karasuno				Karasuno Millington
Create diverse shaping	Gibbons					Mowbray Karasuno Millington
Operate quick response & Just-in-time	Millington Gibbons Nakashima and Karasuno	Nakashima and Karasuno Spencer			Spencer	Millington Stoll Millington
Reduce labour costs alleviate shortages	Nakashima and Karasuno	Nakashima and Karasuno	Gibbons			Stoll Shima Millington
Flexible production	Nakashima and Karasuno	Nakashima and karasuno	Gibbons			Stoll Shima Mowbray
Operate flexible production	Nakashima and Karasuno	Nakashima and Karasuno		Gibbon		Stoll Shima Mowbray
Improve garment comfort & aesthetics			Spencer	Gibbon		Shima Millington
Eliminate waste						Shima Millington
Customisation						Karasuno
Increase sizing consistency						Millington

Appendix B.2 Summary of the potential benefits of complete garment technology 2001-2008

Benefit identified	2001	2002	2003	2004	2005	2006	2007	2008
Design innovation		Mowbray Mowbray Mowbray	Mowbray Davis	Hunter	Mowbray	Mowbray	Siddons	Tait
Improve fit				Hunter	Mowbray			
Create diverse shaping				Hunter		Mowbray		
Operate quick response & Just-in-time			Davis 2003	Hunter		Mowbray		
Reduce labour costs, alleviate shortages						Mowbray	Siddons	
Flexible production		Mowbray	Davis					Tait
Operate flexible production		Mowbray						Tait
Improve garment comfort & aesthetics		Mowbray						
Eliminate waste							Siddons	
Customisation								
Increase sizing consistency		Mowbray						

Appendix C : Email to knittingingdustry.com

Dear Billy

I've just found "knitting industry" online, and already it's helped me enormously with my research by identifying two companies who have just invested in WholeGarment machinery. This is a really useful resource.

As a PhD researcher at Manchester Metropolitan University. one of my aims is to identify the extent of utilisation of Complete garment technology in the UK.

This information will allow me to

a) Map those companies in the UK who are utilising this new technology to make complete garments
b) Identify companies with whom I can conduct case studies in order to evaluate the utilisation of complate garment technology in relation to garment fit and its impact on product development
c) Identify current anthropometric practices regarding size fit and shaping in the UK knitwear industry.

If you could provide me with the names of any companies you know of who produce complete garments in the UK, I would be extremely grateful or any further contacts or information that might help me achieve these aims

Thank you for your help

Best regards

Kathryn Brownbridge

Kathryn Brownbridge.
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Manchester Metropolitan University
Department of Clothing Design & Technology
Hollings Faculty,
Fallowfield, Manchester. M14 6HR

E-mail: k.brownbridge@mmu.ac.uk
Tel: 00 44 (0)161-247-2704

Appendix C.1 Email to the Textiles Institute

Dear Emma

I am a PhD researcher at Manchester Metropolitan University. One of my aims is to identify the extent of utilisation of Complete garment technology (Shima seiki WholeGarment and Stoll Knit and Wear) in the UK.

This information will allow me to

a) Map those companies in the UK who are utilising this new technology to make complete garments
b) Identify companies with whom I can conduct case studies in order to evaluate the utilisation of complate garment technology in relation to garment fit and its impact on product development
c) Identify current anthropometric practices regarding size fit and shaping in the UK knitwear industry.

can you provide me with the names of any companies you know of who produce complete garments in the UK, or any further contacts or information that might help me achieve these aims.

Thank you for your help

Best regards

Kathryn Brownbridge

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E-mail: k.brownbridge@mmu.ac.uk
Tel: 00 44 (0)161-247-2704

Appendix C.2 Email to Machine builders

Dear Richard

I am a PhD researcher at Manchester Metropolitan University. One of my aims is to identify the extent of utilisation of Complete garment technology in the UK.

my research aims to evaluate the way knitwear manufacturers use body measurement to size the garments they produce and how garment fit is achieved when utilising new machine technology. WholeGarment technology was chosen as there are implications that a new way of shaping garments will emerge through its use. Very little is known about the possible impact on product development. So far there seems to be evidence that innovative products are being produced here in the UK.

The first research aim is to identify the extent of the utilisation of complete garment technology within the UK. This will give the project validity as it will provide evidence that the machinery is being used in an industry that has been hit hard by cheap imports. In view of this can you provide me with any of the following:-

a) Sales figures of WholeGarment machines in the UK and/or globally.

b) A list of knitwear manufacturers who have purchased WholeGarment machinery. (I am conducting case studies with companies utililsing the technology. So far two have been completed with Quantum and John Smedley).

c) A definitive figure of manufacturers utilising the technology in the UK and/or globally.

In anticipation I thank you for your support.

Kathryn Brownbridge

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Appendix C.3 Case Study Sampling frame

Appendix D Prompt for telephone with machine builders.

Introduction: –

- name is Kathryn Brownbridge
- currently conducting PhD research at Manchester Metropolitan University.

Aims of research :–

The project will evaluate the way knitwear manufacturers use body measurement to size the garments they produce and how garment fit is achieved when utilising new machine technology. WholeGarment technology was chosen as there are implications that a new way of shaping garments will emerge through its use. Very little is known about the possible impact on product development. So far there seems to be evidence that innovative products are being produced here in the UK.

The first research aim is to identify the extent of the utilisation of complete garment technology within the UK. This will give the project validity as it will provide evidence that the machinery is being used in an industry that has been hit hard by cheap imports. In view of this can you provide me with any of the following:-
a) Sales figures of WholeGarment machines in the UK and/or globally.
b) A list of knitwear manufacturers who have purchased WholeGarment machinery. (I am conducting case studies with companies utilising the technology. So far two have been completed with Quantum and john Smedley).
c) A definitive figure of manufacturers utilising the technology in the UK and/or globally.

Thanks for help so far.

Appendix D.1 Interview Themes (machine builders)

The UK industry.

There are reports that UK companies are utilising the technology (Mowbray 2004a; Mowbray 2005b; Mowbray 2005c; Mowbray 2006a; Siddons 2007). The what extent is the technology being taken up?

Fit Issues

There are various reports claiming that Complete garments offer the wearer improved fit and draping qualities. (Nakashima and Karasuno 1996; Choi and Powell 2005; Shima 2005; Stoll 2006; Shima 2007)

Sizing Issues

There have been claims that the machines eliminate sizing issues. These are unsubstantiated (Mowbray 2005a; Stoll 2006).

Technical issues

Using an alternating needle selection when knitting complete garments produces a less elastic fabric than that of fully fashioned garments (Mowbray 2004a). Faults and defects in a 3D garment are likely to lead to the whole garment being discarded (Nakashima and Karasuno 1996)

Concept garments

Both Stoll and Shima Seiki produce collections of garments (Mowbray 2002; Shima 2005; Stoll 2006; Shima 2007).

Shaping and design

Documentation suggests that complete garment technology can shape a garment in ways that could innovate the knitted garment (Nakashima and Karasuno 1996; Choi and Powell 2005; Shima 2005; Stoll 2006; Power and Otieno 2007; Shima 2007) High labour cost countries are recommended to produce a value added product (Gibbon 1995; Nakashima and Karasuno 1995; Nakashima and Karasuno 1996; Mowbray 2004b). It has been estimated that knitwear manufacturers may only be using 0.01% of the full capability (Chapman 2002; Mowbray 2002; Mowbray 2006b). WholeGarment technology has been promoted as having the ability to produce a completely new class of knitwear

The Consumer

Attitudes to the consumer are reported to differ between the two machine builders Shima (Choi and Powell 2005; Stoll 2006; Shima 2007)

Low Labour Cost

Complete garment technology allows the manufacturer to lower the cost of labour (Mowbray 2004a; Mowbray 2007). Is the technology being utilised for this reason or because it can create an innovative product?

Skills and training issues

There are expectations within the industry that the introduction of complete garment technology will create issues relating to skills, particularly whether personnel designing for and programming the technology will be able to develop the skills to fully utilise machine capability (Brackenbury 1992; Black 2001; Mowbray 2002; Siddons 2007). .

Mass Customisation

Shima Seiki are promoting complete garment technology as having Mass customisation capability (Shima 2005; Shima 2007). Has this been taken up in the UK?

Appendix D.2 Schedule for interviews with the machine builders

This research is being carried out by Kathryn Brownbridge at Manchester Metropolitan University
By answering these questions you are agreeing that the information given can be used within my PhD thesis.
The returned questionnaires will remain confidential and interviewees and the companies they represent will remain anonymous within the text of the interview analysis.
I acknowledge that your time is precious and thank you in advance for your contribution to the research

Aims

The research is in two stages. The first stage is aiming to establish the extent to which WholeGarment technology is being utilised by the industry and whether the technology is being used to improve size and fit and innovate knitwear design.

The second phase of the research will examine consumer attitudes to the size, fit and shaping of knitwear and specific attitudes to WholeGarment knitwear.

The information collected throughout the research will inform a PhD thesis, advising on the use of body measurements when producing WholeGarments in relation to consumer preferences.

Questions

Please answer the questions by typing in the boxes underneath each question.

Personal Details							
1	What is your name?						
2	What is your Job title?						
3	What are your areas of expertise? Please put a cross in the box(s)						
Technical		Sales		Design		Training	
Please explain in writing your role within the company							

The extent of the global utilisation of WholeGarment Technology	
4	To what extent do you think WholeGarment technology is being used with the global knitwear industry?
5	How many companies are using WholeGarment technology globally?
6	How many WholeGarment machines were sold in 2006
7	Are the sales in WholeGarment machines increasing on an annual basis? (If yes please indicate how much in terms of percentage)
8	In global terms which country has invested the most in WholeGarment technology?
9	How many companies in this country now have WholeGarment machines?
10	In global terms which company has made the most significant investment in WholeGarment technology?
11	What is your perception of the UK knitwear industry?
11	Does the English language play a role when training personnel in Europe to use new Shima Seiki technology?
12	How many companies in the UK are using WholeGarment technology?
13	Do you think the market for WholeGarment technology in the UK is expanding?
Customer Satisfaction	
14	What factors are motivating companies to invest in WholeGarment technology? (E.g. Labour saving capability, the minimisation of waste, The ability to innovate design)

15	Are those companies that have invested in WholeGarment satisfied with the technology? I.e. does it meet their expectations?
16	How much feedback do you get from companies using WholeGarment machines?
17	What factors cause the greatest degree of dissatisfaction? (e.g. training/skills difficulties) What factors cause the greatest degree of satisfaction? (e.g. labour saving, new design capability)
18	Do you think that companies who are utilising WholeGarment technology are exploiting the full capabilities of the machinery?
Size and Fit Issues	
19	The Shima Seiki website claims that the use of wholeGarment technology allows for a superior fit. Can you elaborate on this statement?
20	Shima Seiki also claim that whole garment technology blurs the boundaries between knit and textiles and opens out areas of new design. What is your perception of this statement?
21	What key body dimensions are used when making a garment pattern for WholeGarment technology
22	Do Shima Seiki use size charts?
23	Where do Shima Seiki access body measurement data from?
24	Are there any factors about wholeGarment technology that cause the knit structure of the fabric to change and therefore impact on fit when compared to more traditional methods of production?
Shaping and garment design	
25	What are the main reasons for Shima Seiki producing a sample collection
26	Is it possible to download patterns from the Shima Seiki website? Do you think your customers would use this facility?
27	Fully fashioned knitwear tends to be very traditional in its design. Are whole garment machines able to provide the garment producer with more flexibility when shaping a garment?
28	What shaping can be achieved when using WholeGarment technology that previously was unavailable?
29	Are the companies who are making WholeGarments interested in Seam free tags?
30	Do you think that the consumer / retailer will be impressed with garments that are seam free?
32	Do you think 'Seam free' is a good marketing tool or are there other factors that are more appealing?

33	Do you think whole garment Technology produces a Value added (superior) garment?
34	Is the knitting time of a garment too important to encourage experimentation with innovation?
35	In terms of garment shaping do you think that whole garment technology can innovate knitted garment design?
36	Are producers that are using WholeGarment technology developing new ideas for garment design and do you foresee this become a competitive area?
37	Do you predict that whole garment technology will produce a completely new class of garment in the future?
38	What do you think are the prohibitive factors that will hinder innovation? (E.g. Lack of skills, Investment).
39	Which sector of the market do you expect to be the most innovative? (e.g. Sportswear, fashion, technical)
Low labour cost.	
40	Was whole garment technology developed primarily to reduce the labour cost for companies having to compete with cheap imports?
41	Does the utilisation of whole garment technology allow a Just-in-time production strategy?
42	Are your customers using it in this way?
Skills and training	
43	Do you think that there are enough skilled personnel within the global Knitwear Industry to be able to fully exploit wholeGarment capability?
44	Do you expect companies buying WholeGarment technology to invest in training?
45	How much training do companies receive when wholeGarment technology is purchased?
Mass Customisation	
46	Do Shima Seiki recognise that wholeGarment technology could be utilised for mass customisation?
47	Are there currently any companies using the technology in such a way?
48	Have Shima Seiki carried out any developments using scanning technology in conjunction with knitting technology?
That is the end of the interview. If you have any further comments please add them in the box below. Thank you very much for taking the time to answer these questions your co-operation is greatly appreciated.	

Appendix E Interview schedule for case study interviews

This research is being carried out by Kathryn Brownbridge at Manchester Metropolitan University

By answering these questions you are agreeing that the information given can be used within the PhD thesis.

Any sensitive data will remain confidential and interviewees and the companies they represent will be anonymous within the text of the interview analysis.

I acknowledge that your time is precious and thank you in advance for your contribution to the research.

I Agree that the information given in this interview can be published within a PhD thesis or academic paper.

Signed………………………………………………………………

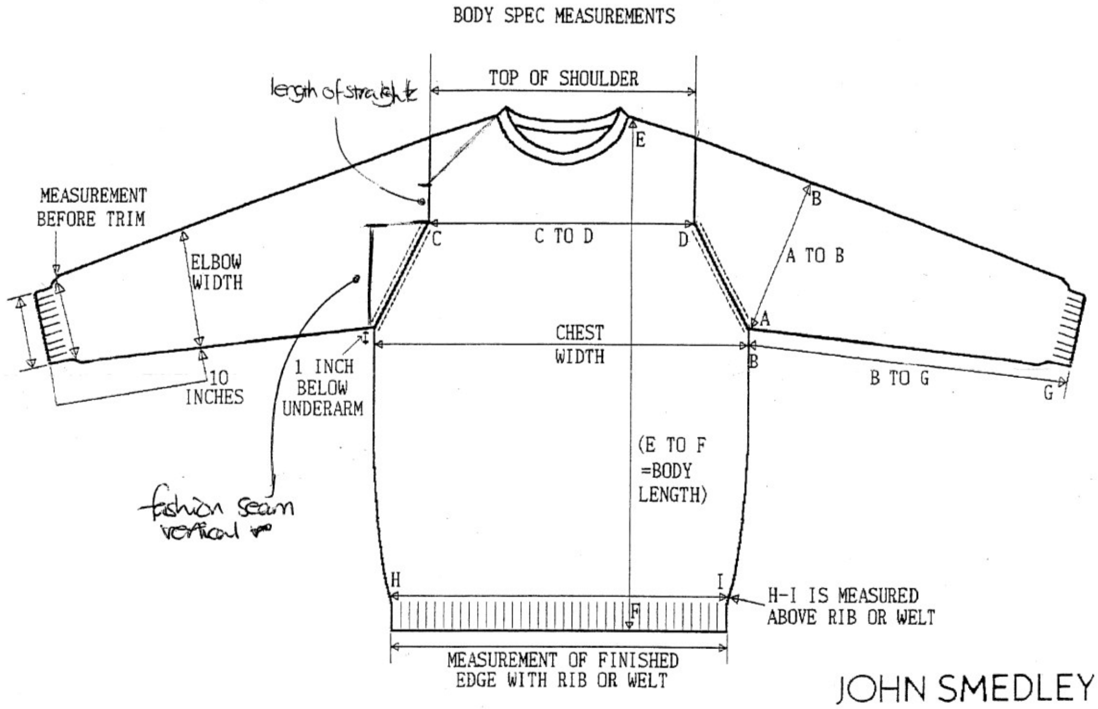
The impact of complete garment technology on workload	Prompt questions
Introductions	
1) What is your name? 2) What is your company position?	
3) Does the utilisation of complete garment technology change the workload expected from the technical team?	If yes, how
4) What training is conducted when a new employee joins the company?	Is it adequate? Where did the training take place? Is there on-going training?
6) Do you ever go to Japan for training courses?	
7) Do you think it's necessary to regularly update your skills?	
Impact of complete garment technology on the sizing process	
8) Has the introduction of complete garment technology had an impact on the garment sizing process	If yes how?
Impact on fit of a garment	
9) Has the technology had any impact on the ability to create garments that fit the body?	How?
10) Do you expect garment fit to progressively improve as the skills to utilise the machinery develop?	
Shaping	
11) What are the implications of using a complete garment machine compared both to fully fashioned and cut and sew garments in terms of ability to shape?	Limitations? Capabilities?
12) What functions are there on WG machines that allow for a more complex shaped garment?	
13) What are the factors that restrict complex shaping?	Cost? customer acceptance? Machine limitations?
14) Do you take a different approach to creating the garment now it's a 3D process?	
15) How many different methods are there to create shape on a whole garment?	Fashioning, changing stitch, adding needles etc.
16) Can you explain the way a yoke is created in simple terms?	Parachute?
17) What are the technical reasons for the difficulties when creating cardigans?	Will you be able to develop new ways?
Product development	
18) Does the process of product development need a different approach when using WholeGarment?	
19) Shima have said that companies using WG technology started by copying the fully fashioned garment, but now they're beginning to develop new ways of producing garments. Does this apply to you?	How is this process changing and why?
20) How much do the sample garments that Shima make influence the Hawick cashmere product?	Are they a useful resource?
21) How would you describe your working relationship with the designers?	Do you work as a team?
22) How does the working relationship between the designers and the technicians affect the product development process?	
23) Do you predict a new type of knitted garment/product developing through the use of	Which sector?

WG technology?	
24) Is the design of whole garments at Hawick Cashmere influenced by how fully fashioned garments look i,e. fashioning lines are used where they aren't strictly necessary.	Do you expect that as the use of WholeGarment technology evolves this phenomenon will change?
25) What are the restrictions to creating new and innovative garments?	
26) Shima believe that Whole Garment technology produces a value added product. What is your perspective on this?	Pointelle?
27) A statement in Knitting International predicted a new class of garment immerging with the use of WG technology. Do you agree?	
Research and development	
30) do you think that the Japanese are more advanced in their approach to product development using WG technology?	
31) Have Hawick Cashmere been involved in any R&D utilising WG technology?	If so what was it? Was it successful?
40) Do you think R&D would be worth investing in more seriously?	
Anthropometric data	
41) How is body measurement used when developing garments?	Grading process?
42) What body measurements are used when constructing knitted garments?	
43) What size charts do you work with?	
Fitting	
44) How are the garments assessed for fit?	
45) What factors during the production of the knitted garment do you have to allow for when sizing a garment?	Pressing? Dyeing?
46) Do you ever have complaints because of ill fitting garments/badly sized?	Is the customer satisfied
Properties of the knitted fabric relating to size and fit.	
47) How do you calculate the eventual dimensions of a garment for each different knit structure/change of stitch e.g. Pointelle, rib	
Machinery	
49) What type of Shima machines do you have in the plant?	Reason for choice
51) Do you think there's a danger that the machinery will become outdated as the technology developes?	
Carbon footprint	
52) Do you think the waste free aspect of WG technology will be a valuable marketing asset in the future?	Does it go further than just marketing?
Mass customisation	
53) The Shima website suggests that WG machines make mass customisation possible. What's your view on this?	
54) Have you been to the boutique in Japan?	
The consumer (last set of questions)	
55) Do you think the consumer is aware of seam free garments?	
56) Do you think seam free is a marketing asset?	
57) What consumer information would be helpful to Quantum?	
Drawing Interview to a close.	
Do they want to add anything?Thank Interviewee Ask if there if further questions can be followed up.	

Appendix E.1 Garment observation checklist

Company	Image 1
Range	
Garment description	
Garment size	Source of images
Knit structure	Image 2
Special features	
Other comments	

Appendix F KM2 garment Specification document



B - D = entire armhole

Specification Y296 CYCLAMEN WOMENS LS SHIRT Revised 16/08/07

Size/Age	SML	MED	LGE	XLG	XXL
TASSEL	82W	88W	94W	100W	106W
CHEST WIDTH - FLAT	41.00	44.00	47.00	50.00	53.00
BODY LEN E-F INC 4 WELT	57.00	59.00	61.00	61.00	63.00
SLEEVE LEN B-G INC 7 WELT	45.00	45.00	45.00	45.00	45.00
SLEEVE AT WIDEST A-B	14.00	15.00	16.00	17.00	18.00
TOP OF BASQUE MEAS	39.00	42.00	45.00	48.00	51.00
ACROSS FRONT FASHION POINT C-D	32.50	34.00	35.50	37.00	38.50
TOP OF SHOULDER WIDTH	34.00	35.50	37.00	38.50	40.00
WAIST WIDTH	37.00	40.00	43.00	46.00	49.00
NECK DROP	7.00	7.00	7.00	7.00	7.00
NECK WIDTH (SEAM TO SEAM)	16.50	17.00	17.00	17.50	17.50
BACK NECK DROP	1.50	1.50	1.50	1.50	1.50
CUFF WIDTH	9.00	9.00	10.00	10.00	11.00
RIB DEPTH NECK	6.50	6.50	6.50	6.50	6.50
FROM WAIST TO TOP (WAIST TO TOP)	36.00	37.00	37.00	38.00	38.00
ARMHOLE B-D	19.00	20.00	21.00	22.00	23.00

INTEGRALLY KNITTED CUFF.

Appendix G KM3 Garment specification document

Design - Forms

HAWICK CASHMERE CO. LTD.

R B **STYLE REGISTER** SPECIAL ORDERS

spare name

view style names on register

STYLE NAME	*KEIRA*
STYLE NUMBER	LC-1-0414-S06
BODY SHAPE	4602(REV)
QUALITY	2/28 CASHMERE
GAUGE	12N X MACHINE
PROTOTYPE	HCC/41/SS2006
CUSTOMER	HAWICK CASHMERE C customer special
CUST. WK TKT.	
SEASON	AW/2006 D/O/S 17/01/2007

FLAT KNIT - NORMAL TENSION

pressing	BOARD
SIZING	UP
WASH CARE	NORMAL
GENDER	LADIES

SPEC LIST

Gauge x

Prod Month 01-

Spec Required

No of units requiring spec:

ORDER OFFICE FOLDER: 06/03/2006

1

2

3

4

TRIM DESCRIPTION

1 0.7CM 1/1 DOUBLE RIB ROUND NECK

2

3

4

5

6

7

BODY SHAPE DESCRIPTION

1 LADIES SLIGHTLY WAISTED JUMPER LS

2 FASHIONED SHOULDERS

3 DEEP SET-IN SLEEVES

4 2.3 CM 1/1 SKIRTS AND CUFFS

5

6

7

ACCESORIES

1 NONE

2

SIZE SPECIFICATION

		WHI	YEL	RED	GRN	BLU	WHI	YEL
SIZE THREAD		WHI	YEL	RED	GRN	BLU	WHI	YEL
TICKET SIZE		1	2	3	4	5	6	XXL
KNITTING SIZE		83	87	91	96	101	106	112
BODY LENGTH		54	55	57	59	60	61	63
SLEEVE LENGTH	U/ARM	43	43	43	43	43	43	43
	O/ARM	56	57	58	59	60	61	62
ARMHOLE DEPTH		19	20	21	22	23	23.5	24
SHOULDER WIDTH		32.5	33.5	34.5	36	37.5	39	41
WAIST		37.5	39.5	41	43.5	46	48.5	51.5
SKIRT WIDTH		40	42	44	46.5	49	51.5	54
MUSCLE		14	14.5	15	16	16.5	17	18
LOWER ARM		11.5	12	12.5	12.8	13	13.5	14
CUFF WIDTH		8.5	9	9	9.5	9.5	10	10
BACK NECK		12.5	CUT	CUT	CUT	CUT	CUT	CUT

Appendix H Knitwear questionnaire

1) Do you regularly purchase and wear:

a) T shirts ☐ Yes ☐ No

b) Cardigans ☐ Yes ☐ No

c) Jumpers ☐ Yes ☐ No

d) Knitted dresses ☐ Yes ☐ No

e) Vests ☐ Yes ☐ No

....

2) Please state your age by circling the appropriate category below

a) 18-25 b) 26-32 c) 33-40 d) 41-48 e) 49-56 f) Over 57

....

3) Please state the numerical clothing size you normally select when purchasing garments by circling the appropriate and size below

Numerical size

6-8 10-12 12-14 14-16 18+

4) Please state the descriptive clothing size you normally select when purchasing garments by circling the appropriate and size below

Descriptive size

Extra Small Medium Large Extra

small large

5) Please state your estimated height

6) Please state your estimated weight

7) Please indicate whether you agree or disagree with the following statements.

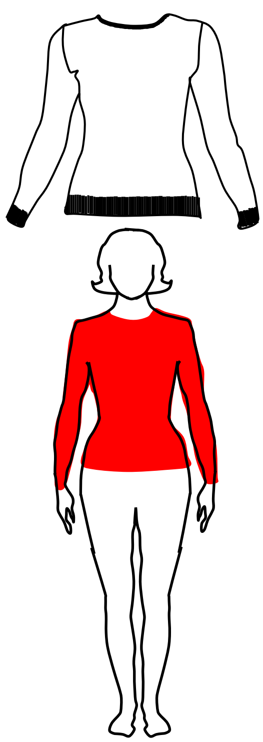
	Strongly disagree	disagree	Neither agree nor disagree	Agree	Strongly disagree
I dress to look fashionable					
I dress to enhance my sex appeal					
I dress for comfort					
I dress to suit my body type					
I choose clothes that disguise my defects					

Tightness of Fit

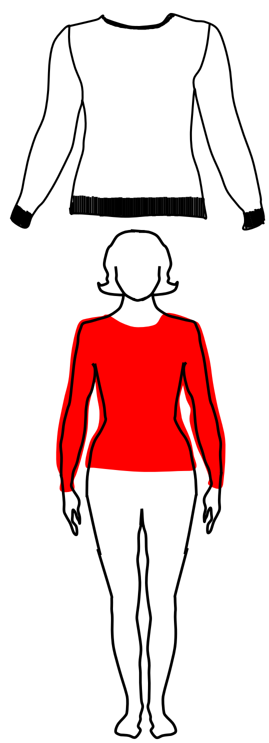
When selecting a knitted top what type of fit are you most likely to choose? (refer to illustration below) Please indicate your choice ticking either often, sometimes, rarely or never in the boxes below

Fit preference	Often	Sometimes	Rarely	Never
I wear fitted knitted tops				
I wear semi fitted knitted tops				
I wear loose fitting knitted tops				
I wear very loose fitting knitted tops				

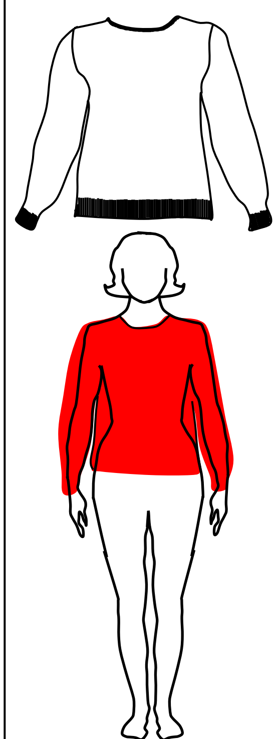
a) Fitted



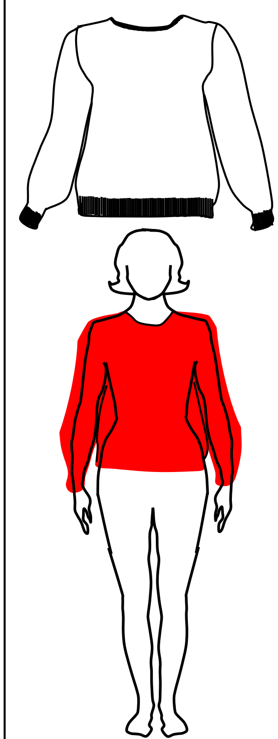
b) Semi-fitted



c) Loose fitting



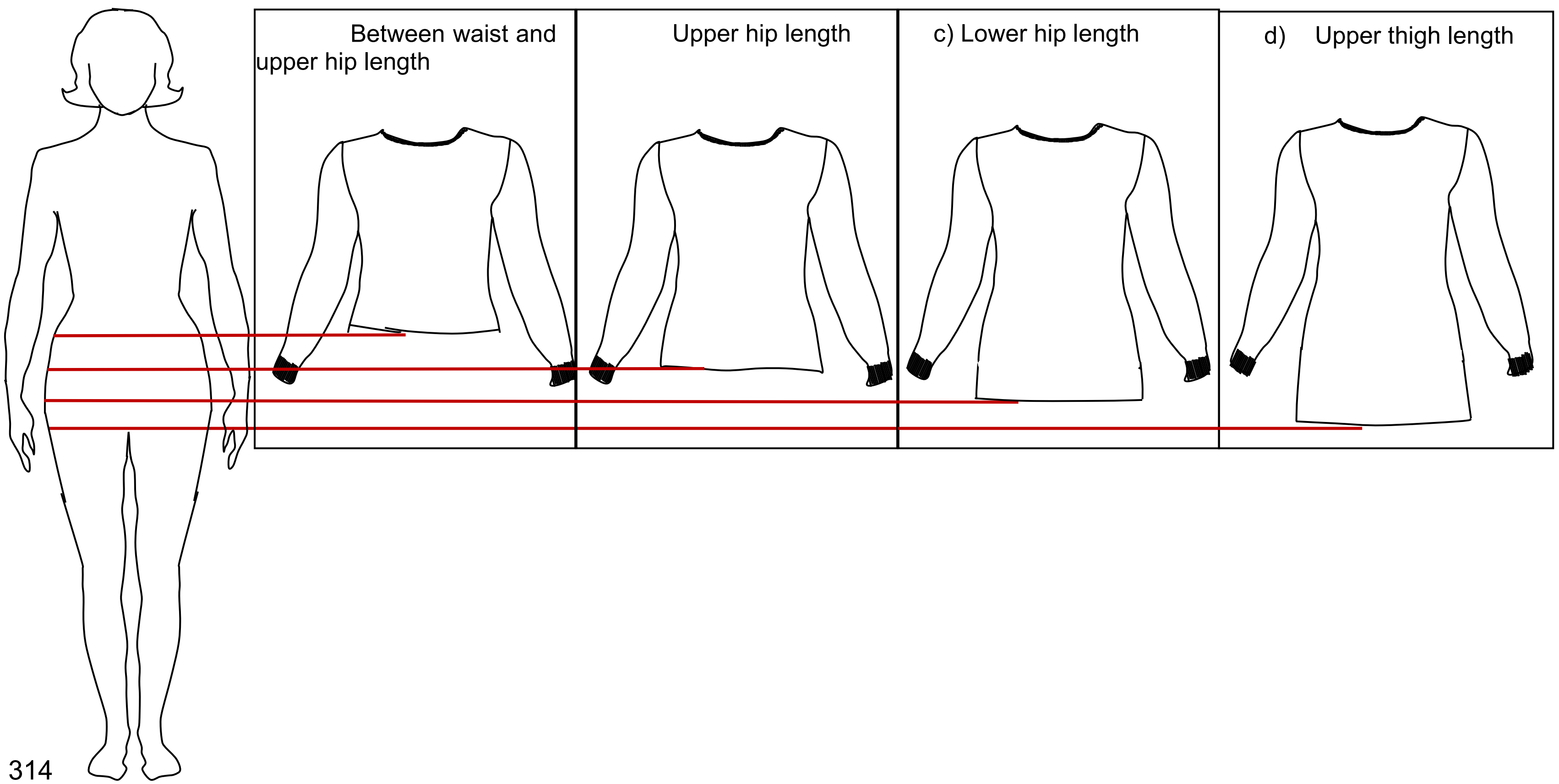
d) Very loose fitting



Length of tops

When selecting a knitted top what body length are you most likely to choose? (refer to illustration below) Please indicate your preference by ticking either often, sometimes, rarely or never in the boxes below

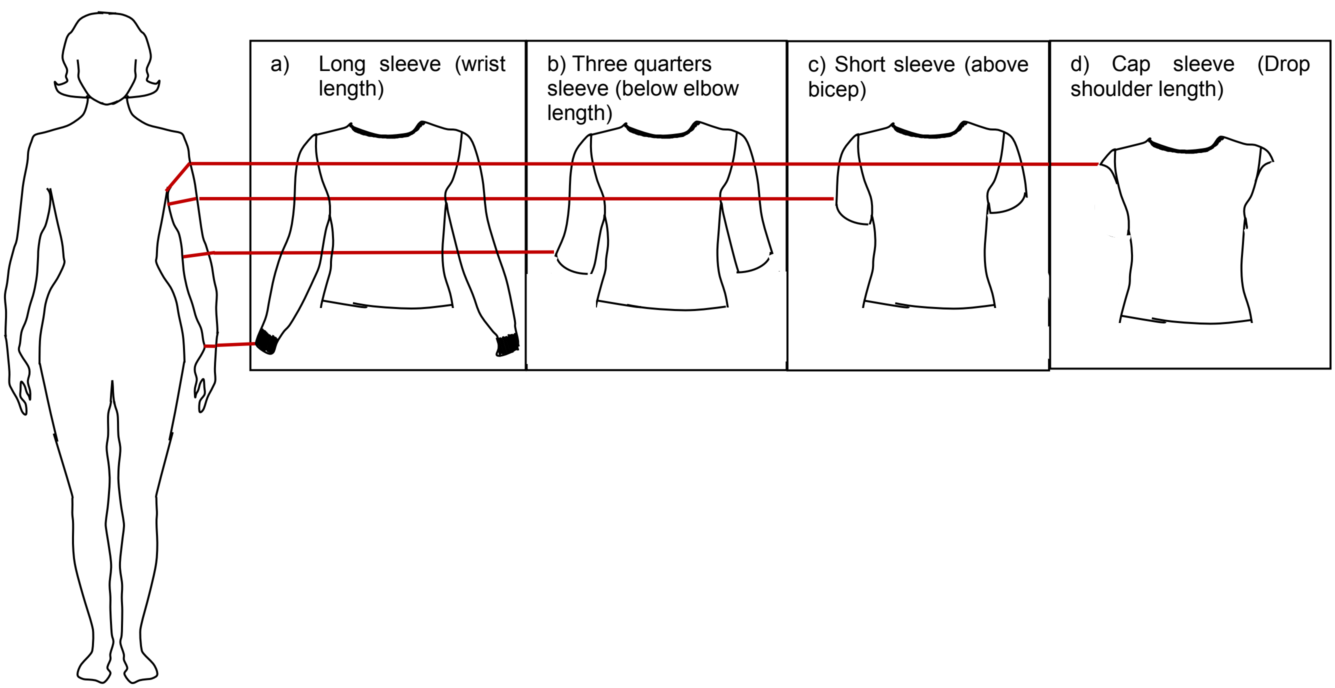
Length of top	Often	Sometimes	Rarely	Never
I wear knitted tops between waist and hip length				
I wear knitted tops upper hip length				
I wear knitted tops lower hip length				
I wear knitted tops upper thigh length				



Length of Sleeves

When selecting a knitted top what length sleeve are you most likely to choose? (refer to illustration below) Please indicate your preference by ticking either often, sometimes, rarely or never in the boxes below

Length of sleeve	Often	Sometimes	Rarely	Never
I wear knitted tops with long sleeves				
I wear knitted tops with three quarter length sleeves				
I wear knitted tops with short sleeves				
I wear knitted tops with cap sleeves				

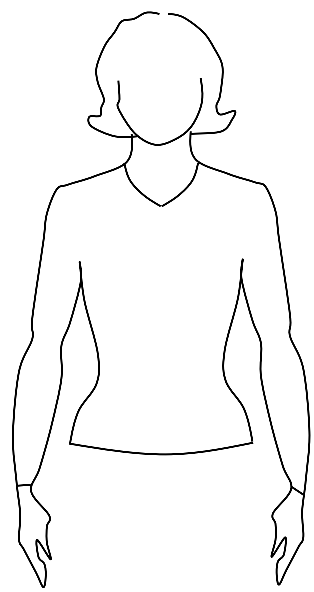


Neckline

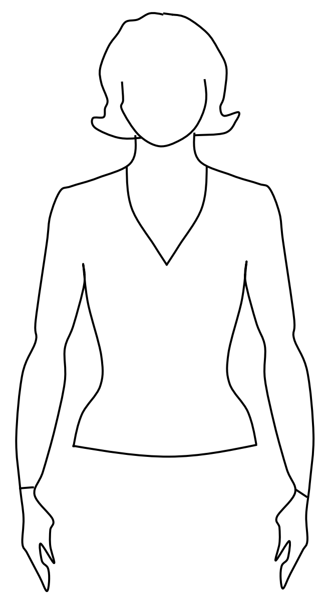
When selecting a knitted top what style of V neck are you most likely to wear? Please indicate your preference for each type of neckline (refer to illustration below) by ticking either often, sometimes, rarely or never in the boxes below

Preference relating to V neck	Often	Sometimes	Rarely	Never
a) I wear knitted tops with a shallow V neck				
b) I wear knitted tops with a deep V neck				
c) I wear knitted tops with a turtle neck				
d) I wear knitted tops with a roll neck				

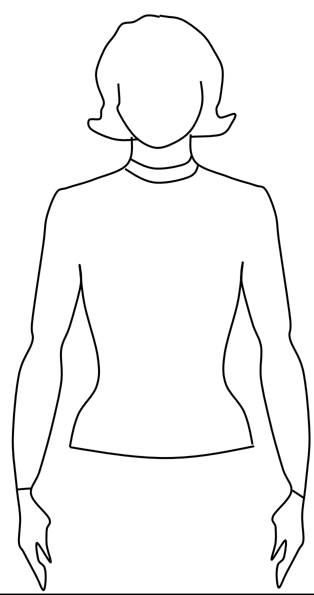
a) Shallow V neck



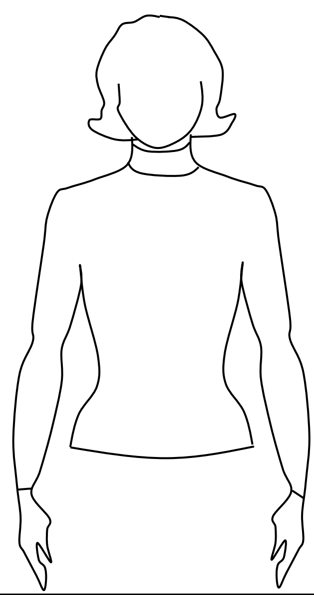
Deep V neck



d) Turtle neck



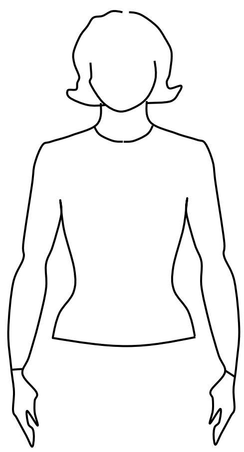
f) Wide deep V neck



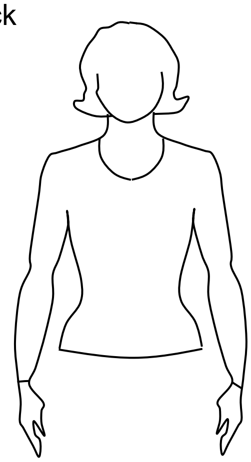
When selecting a round neck knitted top what neckline are you most likely to choose? Please indicate your choice by selecting in order of preference on a scale of 1 to 6 in the boxes below the illustrations (See example below)

Preference Relating to Round neckline	Often	Sometimes	Rarely	Never
a) I wear knitted tops with a crew neck				
b) I wear knitted tops with a shallow scoop neck				
c) I wear knitted tops with a deep scoop neck				
d) I wear knitted tops with a shallow boat neck				
e) I wear knitted tops with boat neck				
f) I wear tops with a scoop boat neck				

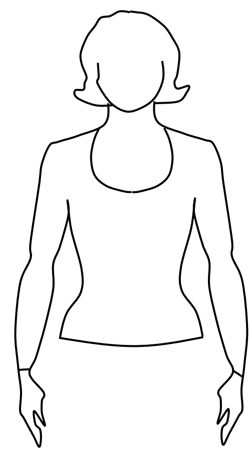
Crew neck



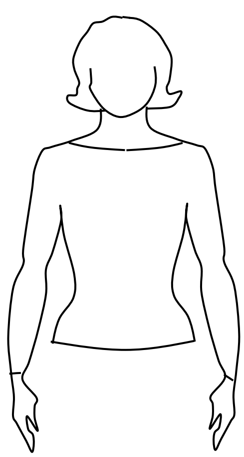
Shallow scoop neck



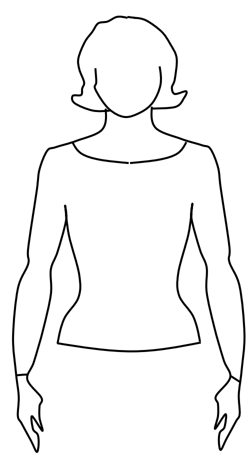
Deep scoop neck



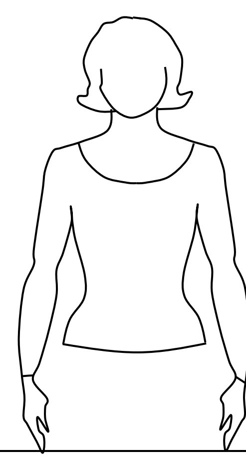
Shallow boat neck



Boat neck



Scoop boat neck

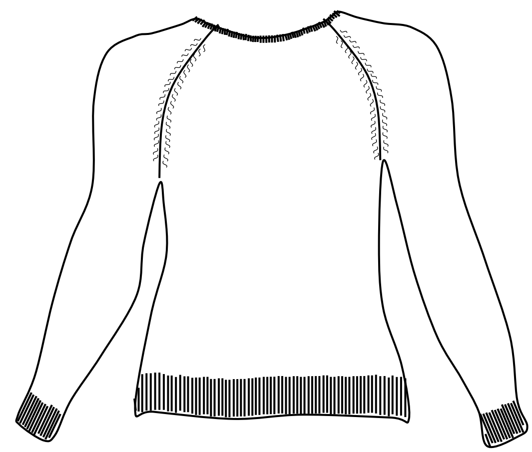


When selecting a knitted top what type of shaping (see illustration below) are you most likely to choose? Please indicate your preference for each type of shaping by ticking either often, sometimes, rarely or never in the boxes below

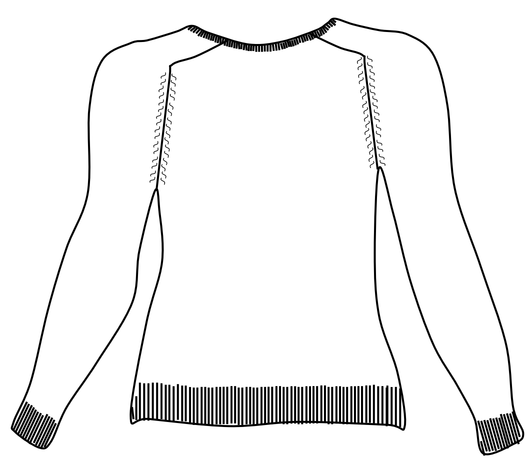
Preference relating to garment shaping	Often	Sometimes	Rarely	Never
a) I wear knitted tops with set in sleeve shaping				
b) I wear knitted tops with raglan sleeve shaping				
c) I wear knitted tops with saddle shoulder shaping				
d) I wear knitted tops with parachute shaping				

Set in sleeve shaping

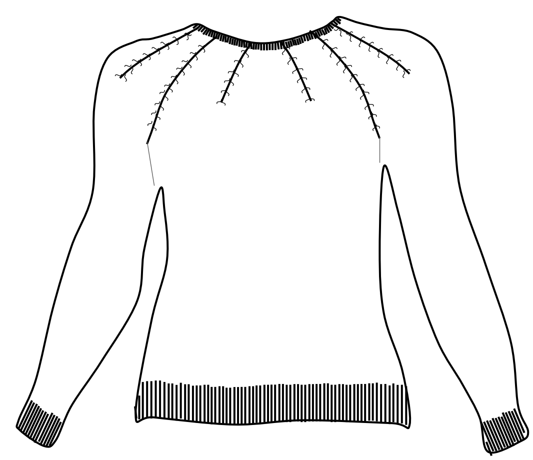
b) Raglan sleeve shaping



c) Saddle shoulder shaping



d) Parachute shaping

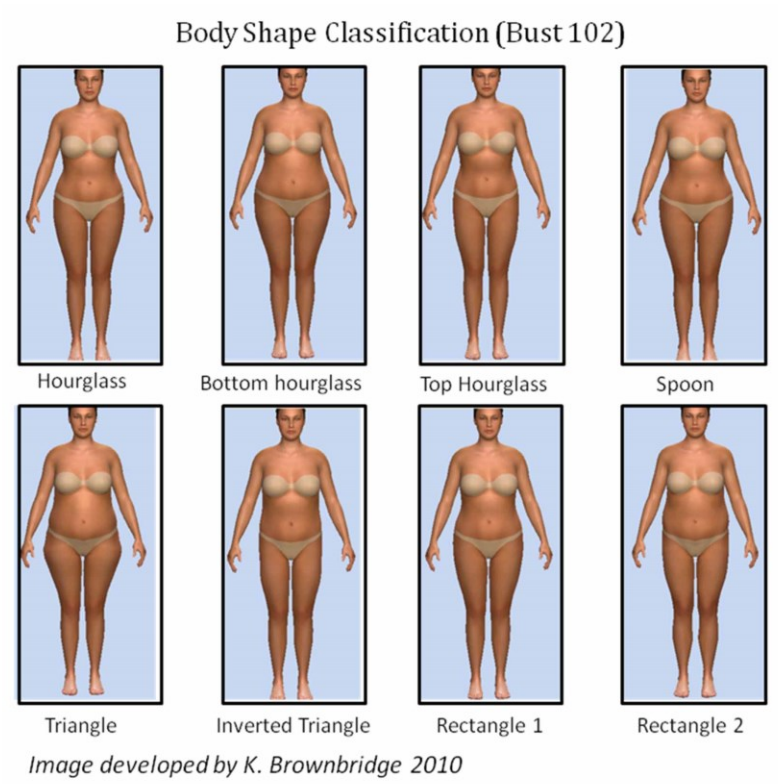


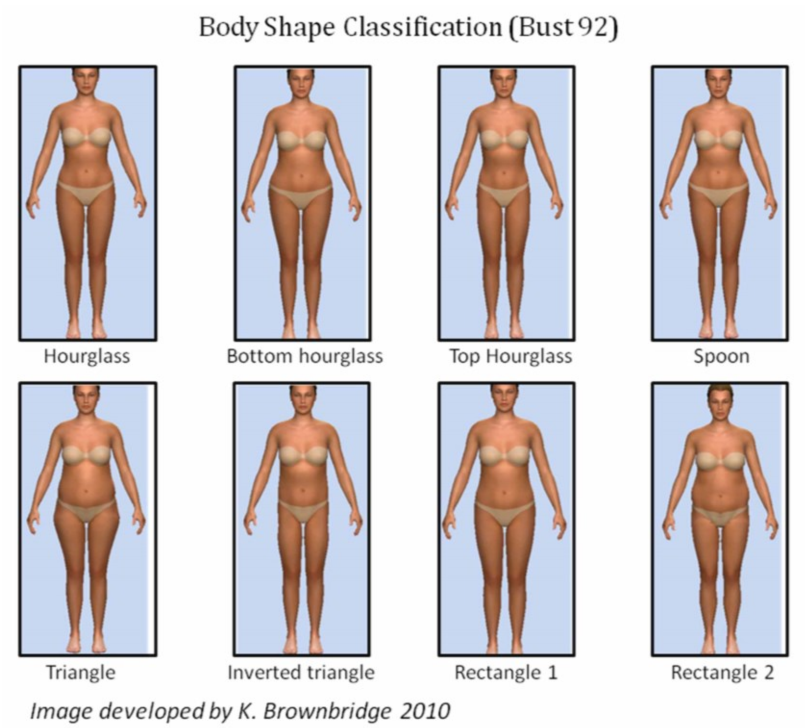
Appendix I Focus group schedule

Question Category	Question	Prompts
Opening	1. State your name and. think of the last item of clothing you bought that made you feel good and provide a short description of it for the group (Garment 1) 2. State Think of the last item of knitwear you bought that made you feel good and provide a short description of it for the group (Garment 2)	
Transition	3. Take a few moments to look and feel the swatches of fabric provided. What names would you use for a,b and c? 4. What language would you use to differentiate between a and b, a and c and c and b? 5. What would you expect these fabrics to be used for? 6. How would you expect these fabrics to influence the fit of a garment? 7. Would this influence your fit preferences?	a) Swatch of woven fabric, b) Swatch of plain knitted fabric c) Swatch of rib fabric
Transition	8. In relation to the last garment you bought that made you feel good, identify the key aspects that influenced your decision to purchase. 9. In relation to the last knitted garment you bought that made you feel good, identify the key aspects that influenced your decision to purchase. 10. The prompt cards provide a set of factors that have previously been identified as influencing consumers when they purchase garments. As a group place them in order of importance thinking about your own personal preferences firstly for woven garment. 11. Place the cards in order of importance for knitted garments	Prompt cards (using themes that emerged from pilot interview)

Key	12. When you purchase knitwear do you find the correct size easily? 13. How do you relate to these various different sizing codes when purchasing knitwear? 14. If you have to select a size that you feel reflects that you are larger than you want to be would you still purchase the knitted garment?	f) Prompt cards with a range of possible size labelling systems e.g. 10,12,14. S,M,L, 32,34,36, 1,2,3.
Key	15. Take some time to scrutinise these garments, what distinctions can you make? (Ask about the distinctions about the way they are made if they do not pick up on anything without this prompt). 16. Have you ever heard of seamless or seam free garments? 17. What would you understand from this term? 18. Can you see any specific advantages of garments without seams. 19. What would attract you buy a seam free garment? Use the prompt cards and place them in order of importance	h) Complete knitted garments (shown inside out) i) Fully fashioned garments (shown inside out) j) Prompt cards with possible advantages of complete garments.
Key	20. Take some time to look at the garments provided. Focussing on garment type e.g. dress, skirt, etc would you wear this type of garment? Please use the yes no voting cards for each garment. 21. Explain your answers 22. Look specifically at the shape of each of these garments. How would you expect each of these garments to fit your body? 23. Do you use knitted garments to disguise or accentuate certain parts of your body?	k) Complete knitted garment (top) l) Fully fashioned garment (top) m) Knitted dress n) Knitted skirt o) Visual images depicting a scale of fit differentiation Yes no voting cards for question 22 p) Prompt card for garment type.
Key	24. Take some time to look at the body shape images provided. Can you categorise your own body shape to match any of these? Please fill in the page and provide your name. 25. How does your own body shape influence the type of garment you choose to wear in relation to how it fits your body? 26. Does the type or structure of the material, knit, weave, rib etc, influence what you choose to wear in relation to your body shape? 27. How does your body image and the possible changes that have occurred over time influence the type of knitwear you choose to wear in relation to how it fits your body?	q) Diagram depicting a range of body shapes in two sizes.
Ending	28. A summary of the output from the focus group is given by the moderator. Is there anything else to add?	

Appendix I.1 Focus group prompt body shape category (Q 21)





Appendix I.2 Focus group prompt cards

Question 10: Factors that influence the purchase of garments (knitted and woven)

Warmth

Comfort

Body shape improver

Status

Fashion

Sex appeal

Drape

Question 12 Size coding preferences

10	12	14
16	18	20

XS	S	M
L	XL	XXL

32	34	36
38	40	42

1	2	3
4	5	6

Question 16: Benefits specific to complete knitted garments

Fashion

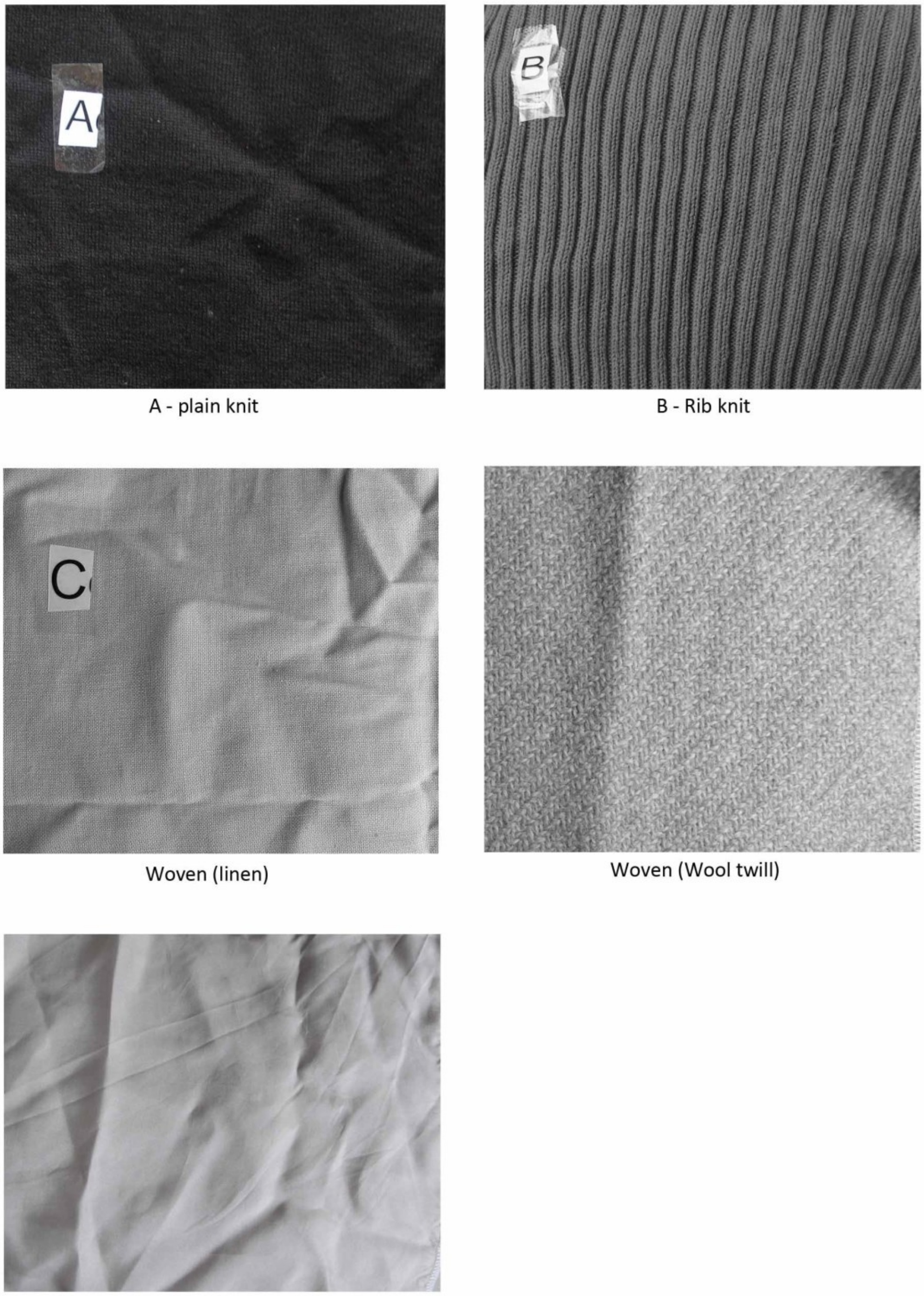
Innovation

Improved fit

Added comfort

Appendix I.3 Focus group prompt: Fabric swatches

Focus Group prop: Fabric swatches



A - plain knit

B - Rib knit

Woven (linen)

Woven (Wool twill)

Woven (Silk habotai)

Appendix I.4 Focus group prompt: Complete garment (dress)

Complete Garment: Dress

Front view

Back view

Front neckline: Trim attached post-production

Rib waistband

Appendix I.5 Focus group prompt: Complete garment (polo neck top)

Complete Garment: Polo top

Front view

Polo neck

Raglan sleeve armhole

Appendix I.6 Focus group prompt: Fully fashioned garment (polo neck top)

Fully fashioned polo top

Front view

Detail showing shoulder and armhole sleeve

Appendix I.7 Focus group prompt: Complete garment (trousers)

Complete Garment: Trousers

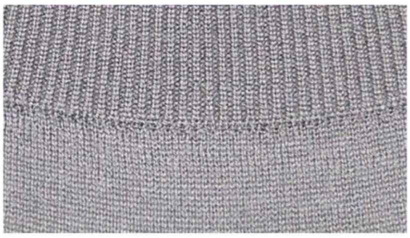
Front view

Front seamless crutch

Detail of crutch construction

Gather on the side of the trouser

Detail of side seam gather



Detail of rib waistband

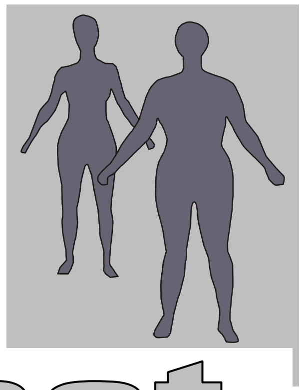
Appendix I.8 Focus group prompt: Fully fashioned garment (trousers)

Fully fashioned garment: Trousers

Front view

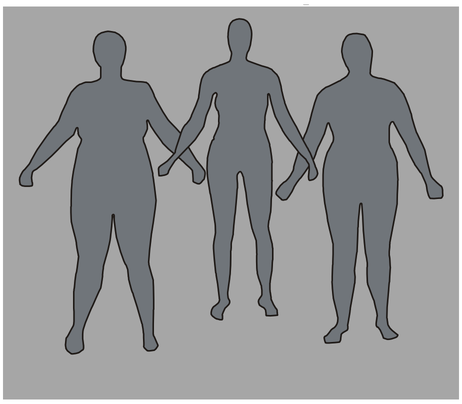
Waistband and crutch seam

Appendix I.9 Focus group recruitment questionnaire



Wanted - Women aged 40-55 to take part in a focus groups study on garment size and fit. (Group interviews one and a half hours long approx)

Have you got opinions about the types of clothing available to fit your size and shape?



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What YOU think?

*If you would like to take part….*Please fill in the details below and I will contact you to arrange a mutually convenient time. (refreshments will be provided).

The information from the focus groups will be used to advise independent academic research conducted for a Doctorate degree at Manchester Metropolitan University. The findings will help to improve knowledge within the field of sizing garments to provide better fit for the target demographic. Your responses therefore could help to bring about improvements. Please complete the form below and return to Kathryn Brownbridge 0161 2472704

Name……………………………………………………………

Contact number………………………………………………...

Age 40-45 46-50 51-55

Size 8 10 12 14 16 18 20+

(Please circle size you most often find fits you).

(These details will remain strictly confidential and only be used for this study

Appendix 8.1 Focus group prompt (Fabric swatches)

Appendix JSummary of comments from focus group Q1

Participant	Garment	Description
P1	Top	Multi layered
P2	Dress	Grey, linen, fitted at the top, strapless dress with ruching and a bow detail, straight skirt. 1950s style, side seams are reinforced with wires.
P3	T shirt	Multi coloured stripe, bought in a heat wave described as comfortable.
P4	Dress	Off the shoulder, worn with a strapless bra.
P5	Dress	Sleeveless, electric blue, ‘floaty’ Cut low under the arms which is a problem as it shows the bra.
P6	Dress	Long, halter neck, purple and gold, ruched and fitted across the bust but loose over the hips and buttocks. The participant does not always feel confident enough to wear this garment as it has to be worn without a bra.
P7	Dress	Short described as having ‘sparkly bits on it’. It fits and flatters the body. No memory of the colour.
P8	Top	Wraps like a shawl, beautiful, purple colour, floral pattern. Described as exotic
P9	Jacket	Black described as funky, stylish and risqué. Tattoo print, silky fabric and fits properly
P10	Cardigan	Pale blue which is a favourite colour
P11	Jacket	Size 16 which is one or even two sizes smaller than is usually necessary
P12	Cardigan	Beige, one sleeve looked longer than the other but when it was tried on it looked good. Stylish, elegant with a roll collar
P13	Cardigan	Hides all the ‘lumps and bumps’
P14	Waistcoat	PVC and rubber with zips, ‘a bit punky’, stylish, reminiscent of ‘how I used to be’
P15	Dress	‘Feels a bit knitted, but it’s nylon’, deconstructed, wild, stylish, eccentric,
P16	Top	Too short to wear as a dress now but would have done 10 years ago. Black with some colour on it, V neck, fitted well which was of prime importance.
P17	None identified	Does not often buy clothes and then they are purely functional
P18	Dress	Unusual print, blue with birds on it. Made from a strong, thick cotton fabric which holds the body in, fitted but not tight. ‘Goes in at the waist’. Liked this shape on her body
P19	Dress	Getting a dress made to get married in. Black or grey still deciding on the style.
P20	Dress	Simple, beautiful fabric, silk with cotton lining. £40 from a discount retailer. Shift shape, good for the participant’s body shape. Vivid colours, lime, turquoise and coral.
P21	Dress	Black, cotton jersey, empire line, V neck flattering on the bust, versatile can be worn for day or night.

P22	Dress	Purple, jersey with a ruffle down the front. The jersey is soft and flattering. Flexible style, cheap and appropriate for work, professional and a bit 'funky'.

Appendix J.1 Summary of Comments from question 2

Participant	**Garment**	**Description**
P1	Cardigan	Peachy orange, fitted with three quarter length sleeves. Can be worn over T shirts in the summer. It was cheap.
P2	Cardigan	Black, fitted, fine wool with gold detail. Versatile and simple.
P3	T shirt	Multi coloured stripe, cool and comfortable
P4	Top	Merril fleece, warm particularly when camping, cheap pleasing colour. (Colour not actually specified)
P5	Cardigan	Steel grey, asymmetric, longer at the front than the back, 'heavy material' which drapes. Covers 'sins' and 'Slims' the upper body (around the ribs) then drapes over the hips. The vertical stripes, (created by the rib) was also noted. Fitted on the shoulder. cheap. Bought when the weather got a bit cooler to wear over summer clothes.
P6	Sleeveless cardigan	Grey, chunky, with cables, cheap from a discount retailer. Fitted on the back, cut out shape at the back, chunky buttons. It covers the hips and particularly importantly the buttocks and was stylish, knee length and fashionable.
P7	Top	Black [interesting the colour is mentioned after being so adamant that colour is not important]. Cut straight across the neckline. (Worn with a turquoise cardigan)
P8	Sweater	Particularly likes the fit and styling, black and white, sixties influenced, has a zip and collar and is cut into the waist and then fits over the hips. Described as funky.
P9	Jumper	(Asked for a definition of knitwear before answering the question) Ten years old and has washed really well, fluffy, the right size and importantly the right length as it is difficult to get jumpers short enough.
P10	Cardigan	Now nearly worn out. Expensive brand, bought in the sale, inky blue, waist length fitted but not tight, not a rib knit, especially likes the elbow length sleeves, 'quirky', 'old timey' with pleasing mother of pearl buttons.
P11	Cardigan	Probably got the wrong idea about knitwear and instantly think of thick chunky which was said to add an extra thick layer which she avoided because of her size. It is therefore the 'thin' knitwear that was currently popular which she is attracted to. Also she is wary of becoming too hot because of her age. Long, black (which goes with everything) and is borrowed by her daughter who is 20.

P12	Cardigan	Woolly, grey/black, 'cuddly and warm' wool mix
P13	Cardigan /throw	Throws over the shoulder. Not a coat or a jumper.
P14	Cardigan	Linen, long, no buttons and pockets on the side
P`15	Dress	Soft, fits to the body
P16	Top	Blue, batwing, fine and meshy, almost transparent
P17	Wrap top	Functional
P18	Top	Unusual, different shape and colour to those normally worn, comfortable, cool and different in fashion terms. Fine knit so not chunky
P19	Jumper	Owned since 1986, which is still in good condition. Only wears knitwear as a functional item mainly for warmth.
P20	Cardigan	Man's second hand cashmere cardigan, £20, not a heavy knit.
P21	Cardigan	Just to throw on. Does not usually buy knitwear because it is difficult to care for. E.g. hand washing and drying flat.
P22	Dress	Fine, not chunky which is not flattering

Appendix J.2 Summary of comments from Question 6

Participants comment	Plain knit	Rib knit	Woven
P1		Could hide your figure	More sophisticated than knitted fabric
P2	Very forgiving, it would gently drape	Appear to increase the size of the wearer. May show bulges - unflattering	Could improve body shape if tailored. Woven garments are more versatile or can create a greater variety of garments, formal
P3	Difficult to tailor, garments do not hold their shape	Difficult to tailor, garments do not hold their shape	Sophisticated
P4	Forgiving, sophisticated, casual	Could 'swamp' the wearer Might result in the wearer looking 'frumpy'. Would be aging if the garment was too big for the wearer. Casual	Could be a shirt.
P5	Very forgiving. Can lose its shape, casual	The heavy weight knit would be unflattering and would create a pear shaped silhouette. Can lose its shape, casual	Unforgiving, creates expensive tailored garments. Wear woven garments to an interview.
P6	Would emphasise body shape, drape. I wear knitted garments on top of other garments.	Could be a quite fitted – fitted jumper. I wear knitted garments on top of other garments.	Will keep its shape. More versatile than knitted fabrics can create of potential garments types and styles, formal
P7	It is less noticeable if the size is not accurate therefore more likely to purchase a knitted garment. Less likely to be restrictive. Wears leggings which are knitted.	Rib is not flattering, the lines created by the knitted structure draw attention to the unwanted curves of the body. If the curves of the body were attractive a rib would be less of a problem.	Sizing would need to be accurate with a non-stretch woven to avoid gaping and pulling etc
P8	Would only wear on top half of the body	Would only wear on top half of the body	More likely to choose woven for 'fatter' bottom half of the body. Prefers stiffer flatter fabric that does not follow the contours of the body.
P9	Avoid for the bottom half of the body	Avoid for the bottom half of the body	Would only wear woven on the bottom half of the body (trousers)
P10	Would hang like a dishcloth if used as a pleated or A line skirt (not suitable). Prefers knitted fabrics for top half of the body. Would be suitable for a wrap dress. Would be suitable for a garment that drapes over the body	Prefers knitted fabrics for the top half of the body but would wear a chunky rib as a skirt in a dark colour with a loose unstructured woven top. A fine rib is like a contour map of all the lumps and bumps on the body. A	Would use the structure of a woven fabric for a pair of trousers that fitted to the thighs. Would be suitable for a 1950s prom dress. Would define and structure the body.

		chunky rib can create structure to a garment, on the cuffs and waist.	
P11		Would not wear a ribbed garment. The lines are thought to be unflattering.	
P12	Would be suitable as a dress		
P13	Would be drapey		
P14			Dresses would have to be A line.
P15			
P16			
P17			
P18	If the plain knit was a rib it would go baggy and could stretch out of shape, but would be comfortable to wear.		The woven fabric would be rigid with no stretch. It would hold its shape and hold the body
P19			
P20	Disagrees that a plain knit garment would stretch out. It could be a wrap dress	Would not be flattering to wear	Would prefer it cut on the bias. Does not mind creasing because it is indicative of natural fibres which are preferable
P21		Would not be flattering to wear	
P22	Disagrees that a plain knit garment would stretch out	Would look hideous	It would crease and therefore would be avoided.