Managing Effective Communication in Knitwear Design

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1 Introduction

Successful communication between different team members is a vital factor for the success of any collaborative work. Often communication fails and the efficiency of the design process and the quality of the product suffer. The strength of a design team often lies in its diversity, but diversity can also made teamwork problematic. Every person has a particular personality and works in a different way; each brings different expertise and experience to the task. Design management must ensure that the diversity of a design team is its strength rather its downfall. This paper presents an analysis of the communication difficulties in the knitwear industry, where a number of problems faced by multidisciplinary design teams in many industries can be seen in particularly sharp relief. It proposes management strategies to alleviate some of these difficulties.

Knitwear design is the creation of a technically complex product according to aesthetic considerations – the relationship between the appearance of a knitted structure and its structural characteristics is subtle and complex. While being an important industry in its own right, the knitwear industry shares important characteristics with both other aesthetic design industries and engineering design. Knitwear design is shared primarily between the designers, who design the visual and tactile appearance of a garment based on fashion trends and customer requirements, and the knitwear technicians1, who are responsible for programming knitting machines to realise these design ideas. The designers undertake the conceptual design of the garment, which as in other industries is usually skeletal, vague and tentative. In developing the knitting machine programs the technicians work out the detailed design. The shape technicians2 construct the cutting pattern for the shape of the garment and assemble the sample garments. (In some smaller companies this job is done by the designers.) The knitwear design team is small compared with those designing complex engineering products, but is typical in different team members have different responsibilities, interests and expertise but their collaboration is essential for the success of the product. In knitwear design significant inefficiencies in the process can be directly attributed to communication problems.

This paper points out the multiplicity and interconnectedness of the factors contributing to communication problems in design. Some of these are difficulties in communicating early

1 Normally referred to as “technicians”. The term is changed to highlight the similarities with the shape technicians.
2 Normally referred to as “pattern cutters” or “make up people”. Both terms are ambiguous, as pattern cutter also is used for the person who cuts garment pieces in production; and make up person also refers to somebody who only assembles the garment in production.
conceptual designs to be found in any field without precise and complete notations. Knitted structures are inherently extremely difficult to communicate, so knitwear designers face task-specific difficulties. Visual appearance and technical realisation are indivisible. An expression of a design without a technical realisation is ambiguous, but working out how the fabric could be created is beyond the designers’ expertise and would upset the division of labour. Designers and technicians think about designs in different terms, in which different aspects of the designs are important. Moreover, they are very different people cognitively and culturally. The culture of the knitwear industry hardly recognises these communication difficulties and does little to counteract them. Sections 5 and 6 explain the various factors contributing to communication problems, and discuss potential changes to the working culture that could remedy them.

Practitioners rarely attribute their difficulties in the design process to a communication problem, rather than a technical problem. When asked why technicians don’t produce what is specified, no designer has given a coherent explanation of the problem in general terms; they referred to the difficulties with particular designs.

As the problem is not recognised by the participants of the design process, it is not addressed in the academic literature on problems in team working. Most research so far has been based on experiments with groups of people working together on one task, where misinterpretations can be discussed (see for example Ullman et al, 1997; Goldschmidt, 1995; Kvan et al, 1997); or on interviews where the participants explain their own views (for example Bushby, 1998). Other observational studies have concentrated on other issues (for example Sonnenwald, 1996, concentrates on roles in design teams).

2 The Study

This research draws on observations in thirteen British, nine German and three Italian knitwear companies, made over a period of four years. The interactions ranged from one-hour interviews with designers and technicians, to observations of design activities lasting up to one week. The methodology combined ethnographic methods developed in the social sciences (see Agar, 1980) with knowledge acquisition techniques from artificial intelligence (see Tunnicliff and Scrivener, 1991), in a model-driven approach to analysing the design process (Stacey and Eckert, 1998). The study covered a wide range of companies, from suppliers to bottom of the market mail order companies to some of the world’s most prestigious knitwear companies. The study placed emphasis on evaluating assertions from interviews and conclusions from observations by talking to different people in the same companies about the same issues, as well as examining the same issues in competitor companies.

The author has also worked on acquiring some of the knowledge, skills and perceptions of the designers and technicians herself, by taking pattern cutting and design classes at De Montfort University, Leicester, attending knitting machine programming courses at Universal GmbH, and by designing garments.
3 Knitwear Design

The analysis of the causes of failures of communication in the industrial knitwear design process presented in this paper forms one part of a detailed analysis of the structure of the process (Eckert, 1997), which was intended to guide the development of intelligent support systems for knitwear design (Eckert and Stacey, 1995; Eckert et al, 1998, in press). In this section we outline how the interaction between knitwear designers and knitwear technicians fits into the whole of the design process.

In knitwear the shapes of the garment pieces are designed at the same time as the fabric. The pieces are either knitted in shape (‘fully fashioned knitwear’), or cut out from rectangular sheets of fabric (‘cut-and-sew knitwear’); and assembled into complete garments in the end. Knitwear design thus combines the scope of fashion design, which is concerned with the shape of garments, and textile design, which creates fabric with woven or printed patterns. The interplay between shape and fabric is the major source of complexity and difficulty in knitwear design.

3.1 The Knitwear Industry

The textile industry is one of the world’s major industries and the knitwear industry is a substantial part within it. Western knitwear companies are under constant pressure from competition in the Far East. (In the late 1990s British retailers have put their suppliers under intense pressure to manufacture abroad to reduce costs.) Like all textile products, knitwear must be designed and produced under tight time pressures. The beginning of a new season in shops sets an unmoveable deadline. Due to the requirements of production and the retail chains’ need to select co-ordinated collections, the design process for a season begins one and a half to two years before garments reach the shops.

3.2 Overview of the Knitwear Design Process

The designers begin working on a new season with what they call ‘research’: investigating the coming fashion trends and selecting yarns from which all the garments in a season are made. They then plan the types of garments they intend to create for the season. Most designers begin what they think of as designing by designing fabric swatches, though many will already think in terms of complete garments. Swatches are later combined into the designs of garments, supplemented by swatches developed for particular garments. Designers create specifications (see section 4.1) for each of the designs they want to see turned into sample garments, in the form of technical sketches. A technical sketch (see Figure 5) is the conceptual design of a garment describing its shape and appearance.

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3 Swatches are little samples of possible fabrics for garments, with new motifs and stitch structures.
The technicians then take over the development. The knitwear technicians program the knitting machine and knit the garment pieces. This involves doing a lot of detail design in the course of interpreting the technical sketch in structural terms; the technicians often deviate significantly from the designers’ intentions. The shape technicians create cutting patterns for the shape, and make up the complete sample garments\(^4\). The knitwear technicians have often already been involved in creating fabric samples to select new yarns and knitting idea swatches for fabrics. Designers evaluate the sample and, time permitting, specify changes to them (see Figure 2).

The finished sample garments are selected internally and often also by external buyers. Only once a decision has been made to produce a design will it be graded (reproduced in different sizes), and adapted for production when necessary.

The knitwear design process is in essence a linear process. Designers and technicians work independently.

\(^4\) Prototypes
3.3 The Intertwining of Design and Technical Realisation

Technical and aesthetic design can never be completely separated in knitwear, even though the work culture imposes a sharp separation through the division of labour between designers and knitwear technicians. A detailed analysis of the influence of the technical properties of knitwear on design is far beyond the scope of this paper. The complexity that knitted structures can have can be seen from textbooks on knitwear technology, for example Spencer (1989). In this paper we are only concerned with why the technical properties of knitted fabric make communicating conceptual designs of garments problematic.

The capabilities of each individual machine limit the space of possible designs; only people who work regularly with a machine know what it can and cannot do. What is possible also depends on the type of yarn; for instance mohair is relatively weak and will break if knitted into an elaborate cable, while attempting the same cable in strong but unstretchable cotton will break the needles on the knitting machine.

Figure 3 Lace Wave Pattern
For many stitch structures the relationship between structure and appearance is hard to predict (see for example the lace patterns in Figure 3). The relationship between different stitch structures can be problematic, for example a when a very stretchable patterns is combined with a tight pattern like a cable. The decorative pattern needs to be placed onto the shape, even though both are designed separately. It is hard to predict for a designer how hard it is knit a pattern by looking at it (see Figure 4).

![Figure 4. Technical Realisation of Cables](image)

Technically Routine: (i) Standard Arran Pattern; (ii) Difficult Technical Problem: Three Groups of Stitches Crossed; (iii) Technically Impossible Problem: Cables with Shadows

### 3.4 Computer Support for Knitwear Design

Industrial knitting machines are among the world’s most complex and expensive machine tools, with around 100 000 parts. Knitting machines are controlled by programs for knitting garments that are developed on highly sophisticated CAD systems produced by the knitting machine manufacturers. Despite marketing claims to the contrary, these CAD systems are mainly built for the knitwear technicians to program the knitting machines, rather than as design tools for designers. Using these systems requires considerable understanding of the technicalities of knitwear design. Modern CAD systems can generate simulations of knitted structures, but only when the program for knitting a garment or a piece of fabric is fully complete. Simulations provide faster feedback than fabric swatches, but the initial communication problem remains. Designers complain that computer simulation does not give the feel of the fabric, and they can visualise the fabric themselves, but praise it for communication and marketing purposes.

### 3.5 The Efficiency of the Process

Practitioners do not normally comment on the efficiency of the process as such, unless they speak about improvements that they have achieved. However the design process appears to be inefficient by the following indicators:
Ratio of Design Ideas to Samples: Ideas are cheap. Each designer produces hundreds or even thousands of design ideas in each season, which they visualise mentally as garments. Only about 50 to 100 designs are specified as technical sketches and about a third of these are produced as sample garments. Of the 20 to 40 sample garments, the retail chain buys fewer than 10.

Technical feasibility of designs: Almost all technicians complain about the designers’ lack of technical knowledge. Only about 30% of all the designs specified as technical sketches can be turned into sample garments than can be manufactured at the specified price point.

Time pressure during sampling: All participants in the knitwear design process complain about having to work overtime before presentation deadlines. They often have to settle for sub-optimal design or technical realisation because iterative improvement is infeasible.

4 The Communication Bottleneck

The communication between designers and technicians is a major contributing factor to the inefficiency of the design process, because designers and technicians cannot specify their designs unambiguously, in a culture that does little to counteract communication difficulties (section 5).

![Figure 5 Industrial Example of a Knitwear Specification](image)
4.1 Specification of a Design

A garment is officially specified in a technical sketch. A particular design only enters the system once this is issued. As Figure 5 illustrates, a technical sketch includes a brief verbal description of the garment, in this case “ladies A-line Tunic”, which is the most reliable part of the specification. It also includes a set of measurements. Designers guess the measurements based on previous garments. They are often an inaccurate description of the designers’ idea. The measurements are often incomplete, because the designers do not know a measurement or leave it out deliberately as an attempt (not always successful) to initiate a dialog with the technicians. The measurements are also mutually dependent, for example sleeve length and sleeve width; and can therefore be inconsistent.

In many companies technical sketches are produced in batches and handed over to technicians without further explanation, relying on earlier unrecorded discussions to give the technician a context for each design.

4.2 Interpretation of Specification

Technicians need to interpret these specifications to create samples or swatches. They trust the short verbal description and interpret technical sketches accordingly. Their interpretation is influenced by the designs that they have produced in the past, which for them are the standard exemplars of categories. With the discrepancy between the seasons that the designers and technicians are working on (see section 6.1), the frames of reference of designers and technicians can be three or four seasons apart. A complete sample garment is produced from the technical sketch. This sample is the only feedback designers get on their designs. They cannot tell whether their garment designs fail to come out as they had envisioned them because of inadequacies in their specifications, or because something else has gone wrong. Therefore they have little chance to improve the quality of the their specifications. Comments on the samples are also the only feedback that the technicians get. As designers and technicians get to know each other over years they will of course get better at understanding each other. Lack of feedback has also been identified by Bushby (1998) as a serious problem in engineering design.

4.3 Mutual Distrust as an Effect of the Communication Bottleneck

Designers and technicians are often dissatisfied with each other. Designers are frustrated that their specifications are ignored, while technicians feel that cannot get designers to give them the information that they need.

Many designers complain that if they specify a new structure, the technician’s initial reaction is “that can not be done”. Later the technician comes back with an entirely satisfactory solution (which may be a significant modification of the designer’s original request). Technicians complain that they often have to waste time to prove to a designer that a certain design can not be produced, when this is entirely obvious to them from the beginning.
Technicians do not trust the designers’ specifications, because they know from experience that the designers often define impossible designs. Several technicians have quoted 30% as the ratio of designs that are technically possible in a given yarn on a given machine at a given price point. With some justification technicians attribute the fact that designers specify impossible designs to their lack of technical aptitude and knowledge.

5 Inherent Reasons for the Communication Breakdown

The difficulties in communication between designers and technicians arise from a number of different factors. Only a complete understanding of all aspects of the problem can inform the design of appropriate computer support tools and strategies.

Communication of knitwear designs is intrinsically difficult - harder than in other textile domains. Designers and technicians have different mental representations and thinking styles. At the same time the pressures of fashion and the length of the sampling process mean that the designers and technicians in a company are working on garments for different seasons. The organisation and physical arrangement of many companies aggravates the communication problems. In many social contexts good personal relations can counterbalance communication difficulties between workers with different interests and expertise, but knitwear designers and technicians are very different people who usually have little social contact outside work.

5.1 Effort and Commitment in Communicating Conceptual Designs

In most design domains an accurate description requires a large investment of effort in working out details, and so a high degree of commitment to a design (Cross, 1989). Knitwear designers typically produce very large numbers of designs, without putting a great deal of effort into any one. The limited investment of effort in describing each design restricts the ability of the technicians to interpret the designers’ intentions once the design is handed over.

A detailed and accurate specification of a design requires committing a significant chunk of the designer’s time to a specific design. By investing this time into a specific design, designers have to change focus away from conceptual design: in the case of knitwear designers, thinking about their requirements, their sources of inspiration, and the demands of fashion.

5.2 Descriptions of Knitted Structures

Sketches are always imprecise and often ambiguous or self-contradictory, and leave scope for interpretation in details. Knitwear designers often use sketches to specify aspects of a design that would otherwise be difficult to describe for example the angle of a raglan sleeve. The rest of the sketch of the garment is often just a placeholder providing the context for the particular aspects that are unusual or important. However, the technicians do not know which part of the sketch contains the important information, and so should be taken seriously and studied carefully.
Model house designs are built from cardboard, model car designs are made in reusable clay, but it is not possible to create a mock up of a knitted garment in another material to communicate the design without creating knitted fabric. Only a swatch can communicate an intended design accurately and give information about how to create it. As the fabric simulations provided by the CAD systems require complete knitting machine instructions (see section 3.4), they cannot be used to communicate design ideas.

Knitwear design does not have a notation that is both easy to use and complete. Designers therefore point to *swatches or garments* to specify what they want, and describe modification to them verbally. The technicians have to reengineer the fabric, which is not a trivial process. This is much more difficult when they have been provided with a *photograph* instead. Designers use *sketches and drawings*, which show proportions and emergent properties, but require interpretation of details. Most CAD systems (see section 3.4) use *colour codes* for different types of stitches, which require technical understanding and learning time to use, while camouflaging the original colours and making certain parts of designs unduly salient. The only complete and accurate notation is the so-called *loop description*, which describes the operations of the knitting machine; it is very clumsy and does not show the appearance of the fabric. Therefore designers often make up their own notations, which only make sense in a given context and describe what they want verbally with reference to other designs. (The use of these different means of expression and their expressive power is described more fully in Eckert, 1997, in preparation).

![Figure 6 Colour Coded Structure](Cable Pattern on the Right) (Shima Seiki, 1996)  
![Figure 7 Loop Description](of Part of a Cable Pattern) (Universal, 1996)

### 5.3 Cognitive Factors

The problem of communicating a mental image of a design to someone else is comparable to trying to explain a picture over the telephone. It is possible to recognise a picture from a description, but unlikely that a complex picture can be recreated from a verbal account no matter how detailed. But this is exactly what needs to happen in the design process: the mental model that the designer has of a garment needs to be translated into a garment by someone else. As a designer has phrased it: “the technicians need to knit what the designers think”.

Because of the difficulties of externalising a design (see section 5.2) many designers explore options at the conceptual design stage by generating and evaluating mental images, often without any sketching. They see the emergent visuospatial properties of the design. The designers have to force themselves to think about the structural properties required to achieve the desired effect. They see a design primarily as an overall concept within the context of fashion, which expresses a pre-decided mood. Designers do not think in abstractions; they
think in terms of complete garments or swatches from the time they start looking at yarn and forecasting material.

Technicians, who have equally good visualisation skills, think about and describe knitwear in terms of the structure of the pattern, as combinations of stitch types, or combinations of machine operations. For example the author has observed a technician changing a cable pattern from Figure 8(a) to Figure 8(b), which has a similar structure but looks very different.

![Figure 8](image.png)

**Figure 8. Different Appearance of Cable Patterns with Similar Structural Properties** (Taken from Burda, 1975)

### 5.4 Ways to Overcome the Specification Problems

If designers could specify designs completely and unambiguously, the need for interpretation would vanish. In the early design process it is necessary that specifications can be created quickly and fluently to avoid forcing the designer to commit too early to an idea, thus restricting their creativity. Eckert et al. (1998, in press) argue that the problem can be overcome by an intelligent design support system, which takes the designers’ customary incomplete and inconsistent specifications and turns them into complete and consistent design specification that can be edited. Figure 9 gives an overview of such a system.
Figure 9 Using a Mathematical Model within an Intelligent CAD System to Overcome the Communication Problems involved in Garment Shape Design

The designers can recognise good specification when they see them, even when they could not create them themselves. Their visualisation ability enables designers to evaluate automatically generated designs. Eckert et al (in preparation) explains in detail the way in which automatic design fits into the work practices and cognitive abilities of designers.

6 Cultural Reasons for Communication Breakdown

At present the organisation and management of the knitwear design process, and the working culture of the industry, exacerbate rather than counteract the idea specification problems that are inherent in knitwear design. Some reasons for this are practical; others are deeply embedded in modern design culture.

6.1 View of Creativity

In both universities and industry the view is held by some people that excessive technical knowledge restricts the designers’ creativity. There is some justification for this view, as technically experienced designers tend to design to the ability of the machines, rather than push them to their limits by demanding novel designs. With increasing expertise designers learn successful design components which they include in new designs as a way of working quickly under time pressure. However there is no evidence that their creativity as such is restricted, rather that designers have found ways to design feasible designs fast.

Many people in positions of influence believe further that artistic creativity is opposed to problem solving ability, and that training in problem solving disciplines harms creativity. To
overcome these prejudices it is necessarily to look at creativity in other fields, and recognise that engineers, mathematicians and scientists can be just as creative as designers (Boden, 1990). These are fields have an understanding that training people in the problem solving skills of their domain can enhance creativity. A wider view of creativity would also increase the respect of designers for the skills of technicians. (See Eckert and Stacey, 1994, for a fuller discussion of attitudes to creativity in the knitwear industry.)

6.2 Record Keeping

The only record of the design process is a technical sketch, such as that shown in Figure 5. Most designers initially produce sketches for their designs, which they tend not to keep; and do not show to the technicians. If designers and technicians discuss designs, it happens in unrecorded conversations in informal situations.

Designers and technicians often communicate by describing changes to old designs, but knitwear companies don’t keep many records of previous designs. Some companies keep all finished sample garments, others only sold garments or selected designs. The technical specifications are kept for one or two years and are then thrown out. New designers have to put significant effort into learning the house style. This is highly problematic as many designers don’t stay in a job for more than three years, because they are afraid of burning out and can often only advance their careers through changing jobs.

The lack of design records has also been identified by Scaife et al. (1994) as a major problem in other parts of the textile industry, which has resulted in the development of computer systems for recording designs. Designers in all companies with good company archives comment on how much they make use of them. Commercial CAD systems for the tailoring industry, such as Gerber (1996) systematically record old designs and make them available to designers as starting points for new designs. At present the obstacle to recording does not lie in the technology, but in the organisational structure of most companies.

6.3 Overlap of Seasons - Different Frames of Reference

![Figure 10 Overlap of Seasons](image)

Designers | Technician | Production | Shops
---|---|---|---
Research N + 3 | Sampling N + 1 | Production N + 1 | Shop N
Design N + 2 | Design N + 2 | |
When the designers begin their research for a new season the technicians are busy sampling the previous season. Production is two seasons behind the designers’ research. As designers and technicians are working on different seasons, they work in different fashion contexts. When problems arise where designers and technicians require the others’ input they are working with different frames of reference and interpret assertions accordingly. Designers spend more time troubleshooting the previous season than researching the new season, but not in an organised manner. Both groups require each other’s support at times when it is not convenient to the other group. This leads to inefficiency and frustration.

Designers and technicians will always be out of sync with each other. However a design process that is more efficient overall is likely to be shorter, so that the discrepancy between the designers’ and technicians’ frames of reference is less. Better record keeping will also reduce the need for interaction and help designers to get back into the mental context of a design.

6.4 No overlapping expertise

Designers don’t receive much technical training in the construction of knitted structures or programming CAD systems during knitwear design courses at college. Many designers are trained in fashion or textile design and are not taught knitwear in depth. In industry only very few designers are trained to program power machines, rather than just how to enter colour designs. Designers acquire technical knowledge piecemeal through practical experience of seeing how their designs are realised. This knowledge is not systematically passed on to younger colleagues. Many technicians have commented to the author that they would like their designers to have greater technical knowledge; they think that better technical training for designers would be the single thing that would improve the design process the most.

Technicians do most of the detailed design of knitted garments when they are translating the designers’ rough specifications into fabric or shapes. Technicians don’t have design training. They rarely have an interest in fashion and don’t follow design developments.

Designers who have attended programming courses claim that they have benefited enormously, because these courses give them a feel for the problems that technicians are likely to encounter, even if the courses are not sufficient for them to program complex garments without a lot a practice. It might be possible to train knitwear designers to program knitting machines, but this would upset the division of labour and increase to workload of the designers so much that they could not concentrate sufficiently on design and research.

Given technicians an understanding of fashion is a significantly harder problem, because the typical technician is not interested in fashion. However in the few companies where technicians are taken along to fashion shows or shopping expeditions, they have picked up a lot of the context for new designs by looking at the same things as their designers (though maybe not for the same reasons).

A more radical approach would be to recruit technicians from the pool of people with both technical ability and artistic and cultural interests, who are normally drawn into other fields like mathematics of computer science. However this would require raising the status and profile of the job.
6.5 Getting Hold of Each Other

In many companies the offices of the designers and technicians are quite a long way apart. When designers and technicians are moved close together designers notice it as a relief. Designers and technicians often have to wait a long time until they can catch up with each other when they need critical input. Designers are often away from their offices, whereas technicians are tied up with machinery. Bushby (1998) has also identified this as a major contributing factor to the lack of feedback in engineering domains.

Some companies have restructured their organisation and physical layout to place designers and sample technicians in one department in close proximity to each other. E-mail and access the Internet is beginning to have an impact on the textile industry. Perry and Sanderson (1998) review recent research on computer supported collaborative work, and argue that effective support for collaboration needs to facilitate informal communication and enable designers to exchange a variety of different information-carrying artefacts such as sketches and schematic diagrams.

6.6 Different social groups

Three main participants share the knitwear design process: the designers, the fabric technicians and shape technicians. They are very different people in most respects, who do not naturally interact. Designers are young university or polytechnic educated women with artistic aspirations in a job that is not highly paid. Almost all technicians are men, who see themselves as working class and have little interest in fashion or other artistic occupations. They are typically recruited from knitting machine operators, and have no education beyond secondary school, even though the job is as challenging as other types of computer programming. They are better paid than designers, which contributes to their generally much higher job satisfaction. Technicians are hard to replace and stay for a long time in the same company. Designers and technicians rarely socialise. They do not discuss problems in casual chat and generally do not know each other well enough to understand how the other group thinks.

Eckert and Stacey (1994) present a more detailed analysis of the gender and other differences between designers and technicians, and their differences in aptitude and access to computer technology. There are exceptions to this pattern, including companies where designers and technicians socialise. Since that paper was written, we have encountered a young female knitwear technician, who said she did not suffer from sex discrimination.

Recruiting different people as knitwear technicians, such as women with degrees in mathematics or computer science, would not only ease the gap in expertise (see section 6.4), but also narrow the social gap between designers and technicians.

6.7 Power struggles between the designers and the technicians

Most companies declare that they are committed to realising the designers’ garments as closely as possible, because the design ultimately sells the garments. However they rarely give the
designer formal power over the design process. It is difficult to find skilled technicians, because few people able to program highly complex CAD systems are to be found operating knitting machines on the shop floor. Colleges and universities produce a surplus of designers, and designers find it difficult to get a job. Companies don’t have problems recruiting skilled designers, but sometimes find it difficult to find designers with management skills. This difference in job security gives the technicians power over the designers who know that if they antagonise the technicians, they are likely to leave and not the technicians.

Recruiting technicians from the shop floor limits the choice of able people; however programming a knitting machine is not any harder then using other CAD or drafting systems, and changing the recruitment strategies would help significantly.

6.8 Skill Profile of Design Managers

With few exceptions managers in the knitwear industry are neither designers nor technicians, but have a background in sales or business studies or no relevant training at all. They cannot assess technical arguments and often only have a partial understanding of fashion. Therefore they cannot mediate between designers and technicians.

Companies increasingly try to recruit design managers who have a background in design, but find this extremely difficult. Industry at present offers little staff development training for designers. A new generation of managers could arise from junior designers. If outsiders are hired into the industry it is imperative that they receive basic training in the domain, so that manager don’t – as happens frequently at present – patronise designers and technicians do camouflage their own insecurities.

Some companies in Germany employ specific people as intermediaries between technicians and designers either on a design manager level or a CAD system operator level; and have been successful with this approach.

7 Conclusion

In knitwear design, aesthetic design is inseparable from technical realisation (see section 3.2). Neither designers nor technicians understand both aspects of design, which limits what they can imagine as well as what they can do (see section 6.4). The full potential of the medium can therefore rarely be explored. We have observed that difficulties in communication between designers and technicians are jointly caused by a variety of different factors, and have a number of significant influences on the design process.

The communication problems in the knitwear industry arise because designers produce incomplete, inaccurate and inconsistent specifications, which require interpretation by a technician. The process is asynchronous so a shared meaning usually cannot be negotiated by extensive direct discussion. At present the interpretation of the specification by the technician is an integral part of the creation of a sample. Therefore designers cannot unpack the feedback they get (in the form of completed sample garments) to distinguish the mistakes in their specifications from the subsequent actions of the technicians. As more and more sampling is
moved offshore these problems will increase unless a clearer way to specify knitted garments can be found. Computer systems can help to specify designs clearly (see sections 3.4 and 5.4).

The culture of the knitwear industry aggravates the communication problem, because designers and technicians do not share the same frame of reference for their work and have very little overlapping expertise. Face-to-face interaction is difficult, because designers and technicians work in different locations; and rarely socialise. Otherwise the author considers the cultural and organisational problems to be secondary to the specification problems. Some fundamental management measures can be taken to alleviate the communication problems:

- Send designers to training courses;
- Include technicians in the fashion research process;
- Recruit different technicians who are mathematical or technical graduates with an interest in fashion;
- Recruit or train managers with fashion and technical knowledge, or train designers in business and management;
- Record previous designs and make them accessible;
- Put designers and technicians in the same location.

We argue elsewhere (Eckert and Demaid, 1997) that a radical reorganisation of the design process in the knitwear industry according to the principles of concurrent engineering would be beneficial. The subjective nature of artistic design limits the applicability of the concurrent engineering paradigm. However the concurrent engineering approach to knowledge management, which promotes openness, sharing of information and pro-activeness by all the participants in the design process can only enhance the effectiveness of the knitwear design process.

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