MASS CUSTOMISATION OF FLAT KNITTED FASHION PRODUCTS: SIMULATION OF THE CO-DESIGN PROCESS

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Abstract:

In 1995, the Japanese manufacturer Shima Seiki introduced the first complete garment knitting machine capable of producing a ready-made flat knitted article under the trade name WholeGarment. Recently, the company also developed a co-design software tool, Ordermade WholeGarment®, for the customisation of knitted fashion garments. Factory Boutique Shima, their retail shop for on-demand production of customised knitted garments, makes it possible for clients to modify a knitted garment according to personal taste in style, colour, pattern and size. This study examines how such a process streamlines the interaction between customer and shop personnel, while expediting the programming of the knitting machine. In comparing the manual co-design process with the Ordermade WholeGarment® system, we used a computer simulation to analyse the efficiency and lead times of each concept. The case study method was employed with an inductive approach based on company visits and interviews.

Key words:

Knitting technology, mass customisation, co-design, complete garment, fashion design, simulation.

Introduction

Technological developments over the past twenty years have opened up new possibilities for the production of knitted fashion products. A flat knitting machine can now manufacture complete garments, eliminating the need for such post-knitting processes as cutting and sewing [1]. The time from yarn to "ready-made garment" is thus shortened considerably, and several non-value-added operations are also rendered unnecessary.

Keeping "time to market" as short as possible is essential if one is to fulfil customer demand [2]. Similarly, mass customisation has been defined by Tseng and Jiao [3] as technologies and systems capable of delivering products that meet a customer's individual needs with nearly the same efficiency as mass production. One of the future directions of the fashion and garment industry appears to lie in mass customisation, but until recently, fit and colour selections have limited its use [4]. Mass customisation of apparel from a customer's perspective is considered by Lee et al. [5] as a technology-assisted process that allows the purchaser to modify a company's product line in order to meet personal design taste or fit requirements. The co-design software tool described in this paper is intended to make such customisation possible.

The business model of Factory Boutique Shima is actively founded upon two systems that engage the customer in the design of a selected item. The result is not only a customised garment, but one manufactured in response to actual demand. Manual WholeGarment is an interaction process that has been in use since the first Factory Boutique Shima store opened, whereby design and customisation are done in dialogue between the customer and the shop personnel, while production equipment is located nearby. In April 2008, a newly-developed "multiple choice design system" called Ordermade WholeGarment(r) was introduced. It offers the buyer a variety of options with regard to style, material, size, colour and attachments. The Ordermade WholeGarment(r) system is the first in the industry that makes it possible to customise a garment and simultaneously transform the buyer's preferences into knitting machine control data. This breakthrough both streamlines the human interaction in the customisation process and eliminates the tedious programming of knitting machines. We examine the two systems through simulations that compare lead time, efficiency and the impact they had on retail sales of complete knitted garments.

Methodology

The inductive method used in this study is based on a survey of the literature, discussions with shop personnel and company interviews. The field work was carried out at the firm of Shima Seiki, supplier of knitting production equipment and inventor of the prototype co-design system Ordermade WholeGarment(r), and the fashion companies Factory Boutique Shima (Wajima Kohsan Ltd.) and SOM Concept. A research project entitled "Knit-on-Demand" at the Swedish School of Textiles, in collaboration with the SOM Concept, was also a source of information [6]. The discussions, interviews, and a study of the co-design process in Japan represent the primary data collection. A literature survey comprised the secondary data. At the Japanese shop, one person acted as a customer and a garment was customised through the co-design process from beginning to end. Thus, information for the development of the simulation model was collected on-site in the real shop environment at Factory Boutique Shima. The customisation processes was studied in two formats: a) Manual WholeGarment co-design, b). Ordermade WholeGarment(r). Both were evaluated and assembled as models for simulation in AutoModTM in order to compare their performance. Qualitative interviews with factory representatives at Shima Seiki and retail staff at Factory Boutique Shima developed information about the two procedures. Verification of the input provided and the results of the simulations are compared with that provided by the three sources. Some limitations of this study may be the

absence of actual customer behaviour in the data and the fact that it is based on a simulation, rather than observation in a real shop environment. The originality and value of the paper is that it compares manual with software-assisted co-design and describes how the latter may be useful for retailing knitted garments in the fashion industry.

Discussion

Mass customisation, co-design and the configuration process

Whether mass customisation can be successfully employed in the knitted fashion product industry remains a contested question. Pine [7] extended Davis's definition of mass customisation to include variety and individualised options that would allow almost everyone to find what they wanted at prices comparable to mass-produced items. The term "mass customisation" has evolved from the familiar "mass production", which continues to signify the manufacture of large quantities of standardised products by the use of assembly line techniques. Mass customisation, however, has been variously interpreted, and there is no precise definition of the term at present [8].

Some modern business concepts for fashion products, shoes and other items have combined contemporary manufacturing technologies with mass customisation. An example of this is the Finnish left(r) foot company, where a customer's feet are scanned by sales personnel. The information obtained is then used to manufacture perfectly fitting shoes that are delivered to the customer's home within three weeks [9]. Another example of mass customisation of fashion products is the Internet-based German company Spreadshirt that sells T-shirts whose graphics are individually designed by customers. Spreadshirt applies these unique designs to a selection of standard T-shirts using modern digital printing technology [10]. Other knitted fashion products can be customised in a similar manner.

Kaplan and Haenlein [11] define mass customisation as a strategy that creates value by some form of interaction between the company and the customer at the fabrication/assembly stage. An approach described by Lampel and Mintzberg [12] is tailored customisation. Here, a company offers a product prototype to the customer and then adapts or tailors it to the buyer's demand. Gilmore and Pine [13] term this a collaborative approach, that is, a dialogue with individual customers to help them identify their needs, after which the manufacturer either designs or customises the product accordingly. Bourke [14], Franke and Piller [15] and Weston [16] have concluded that all known mass customisers use systems that are to some extent IT-based.

Mass customisation interaction platforms consist of three principal components: core configuration software that guides the user through the configuration process by means of questions that offer design options; a feedback tool for simulating the configuration so that the customer may visualise the product and an analytical tool (not seen by the buyer) that translates the customer's order into a list of material and information for production of the product, and then forwards the configuration to the manufacturing and other departments.

In the co-design process, customers convey their preferences and these become the basis of the manufactured product [17]; [18]; [19]. When a customer selects options in a co-design system or "configurator", they become a co-producer or "prosumer", as Toffler explains [20]. In the literature, co-design frequently signifies the interaction of an individual consumer and a company during the configuration of a customised product [21]; [22]; [23]; [24]. Made-to-measure and consumer-driven design are both concepts that have been carried over into mass customisation from the terminology of mass production.

If a business is involved in the sale of mass customised products, the traditional order of development, production and distribution needs to be reformulated from a linear to a concurrent or parallel process [25]; [26]. Closing the sale with the customer becomes one of the initial steps, rather than the final one. Streamlining the time-consuming manufacturing operations after the point of sale is the key to shortening delivery time.

Fiore, Lee and Kunz [27] cite the two essential elements in mass customisation of apparel: co-design for a unique product and body scanning for a better fit. In co-design, the customer, generally with the aid of CAD technology or professional assistance, assembles an individualised product from a company's offerings by choosing style, fabric, colour palette, pattern and size. Body scanning may be employed to obtain or verify measurements if a perfect fit are required. The disadvantages of body scanning are three-fold: a) it requires an investment in specialised equipment, b) not all people wish to be scanned and c) certain types of clothing require taking a customer's measurements manually. The latter procedure enables a dialogue between the purchaser and the sales person regarding the fit of a garment, an aspect often overlooked in promoting body scanning. On the negative side, taking measurements manually can be more time consuming and may raise issues of personal privacy.

One of the bottlenecks in the mass customisation concept for flat knitted products via complete garment technology has been the co-design process itself. Until now, it has involved manual interaction between the customer and the shop assistant throughout the customisation of the garment. A new system that could make the co-design process more efficient and profitable would be welcome.

Factory Boutique Shima - A concept of manual co-design

In 1995 the Japanese manufacturer Shima Seiki introduced the first knitting machine capable of producing a complete ready-made flat knitted garment. The company called their complete garment concept WholeGarment(r). In the same year Wajima Kohsan Ltd. opened the first Factory Boutique Shima, a retail store specialising in on-demand production of customised knitted garments, in Wakayama, Japan. The company added a second Factory Boutique Shima in the same city in 2008. The two shops and their associated manufacturing unit employ about fifty people. Factory Boutique Shima is a business concept that combines knitting technology and mass customisation on the retail level. It enables a client to enter the showroom, design and customise a flat knitted garment, and then have it manufactured promptly in a nearby production facility. The boutique provides customers the opportunity of examining fashion magazines, swatches of fabric, colour charts and sample garments for ideas in custom designing their own garment. A selection of garments in various sizes may also be tried on to assure a perfect fit. Figure 1 shows one of these storefront shops.

Figure 1. Factory Boutique Shima's flagship store, Wakayama, Japan.

In the process of creating the customised item, the client's measurements are taken by a shop assistant skilled in clothing design. The Factory Boutique Shima product line includes a variety of items made by the cut-and-sew, fully-fashioned or complete garment manufacturing methods, with customisation options corresponding to each technology.

The sequence from the retail shop entrance to the point where the custom designed garment is delivered is shown in Table 1.

Table 1. The Factory Boutique Shima customisation concept.

The Factory Boutique Shima concept
Customer enters store
Customer browses through catalogues and examines merchandise
Design and customisation of garment
Order placed and purchase pre-paid
Manufacturing of customised item
Delivery of finished garment

After the customisation process has been completed (Table 2), a customer is still free to decide whether or not to purchase the garment. If an affirmative answer is given, an order is generated and sent to the shop's production unit. This "manually customised" WholeGarment(r) product is then made without cutting or sewing, that is, the entire garment is created in one continuous operation on the knitting machine. Such a manufacturing process will result in a seamless product with a more perfect fit and drape than is possible to achieve in the case of conventionally sewn products.

Table 2. Steps in manual customisation.

Manual WholeGarment customisation in Factory Boutique Shima
Item and style
Choice of material
Neck type
Sleeve length
Size (input of body measurements)
Choice of colour
Attachments
Customisation completed

When a garment has been finalised and pre-paid, it is manufactured as expeditiously as possible, generally the same day. Yarn and other stock components such as buttons and labels are kept on hand. By reducing the number of processes involved, complete garment manufacturing makes it possible to produce a customised garment in less time than conventional methods. In Japan, delivery is generally made by parcel post, but if faster service is required (for example, on orders from abroad), express shipment is used. If shipping is expedited, a customised garment could reach a customer in 3 to 10 days after being ordered, depending on the production schedule and the destination.

Factory Boutique Shima - A concept of co-design via configurator

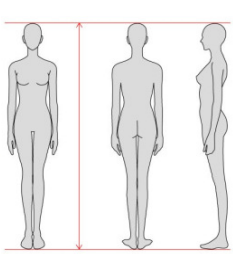
In contrast to the manual procedure just described, one of the Factory Boutique Shima stores has introduced a newly-developed co-design system to make the interaction between the customer and the company more efficient. This process, termed Ordermade WholeGarment(r), enables the client to do more of the customisation independently, via a computerised system. The software tool developed by Shima Seiki is the result of many years of collaboration with Wajima Kohsan Ltd. and the experience gained in selling customised garments in their retail store, Factory Boutique Shima. The Ordermade WholeGarment(r) co-design system functions as an interface between the customer and the manufacturer. Options are presented in several steps, allowing a customer to choose materials, styles, colours and such details as pockets and trims, as shown in Figure 2. This innovative software makes it possible to customise and design a fashion product with much less help from a shop assistant than before. The Ordermade WholeGarment(r) procedure has been used in one of the Factory Boutique Shima shops in Wakayama since 2008. The computer-assisted customer's personally designed garment is co-designed as indicated in Table 3.

Figure 2. Co-design in the computerised Ordermade WholeGarment(r) system.

The ideal scenario is that a customer comes into the shop to examine sample garments, yarn and swatches that are on display. After the prospective buyer decides to create a customised garment, a design technician on the shop's staffs take the customer's measurements and input them into the Ordermade WholeGarment(r) system (Figure 3). Through a process of multiple choices, a garment is designed and

Table 3. Co-design in the Ordermade WholeGarment(r) system.

Customisation in the Ordermade WholeGarment® system
Choice of material
Choice of colour
Item and style
Attachments
Size (input of body measurements)
Customisation completed
Knitting data automatically created by the software
Customised product displayed in the computer



採寸箇所	Measurement	cm
身長	Height	158
バスト	Bust	83
ウエスト	Waist	64
ミドルヒップ	Middle Hip	83
ヒップ	Hip	91
背肩幅	Shoulder Width	39
裄丈（長袖）	Neck to sleeve edge(Full)	72
裄丈（七分袖）	Neck to sleeve edge(Three-Quarter)	61
裄丈（半袖）	Neck to sleeve edge(Half)	40
袖丈	Sleeve Length	52
ひじ下丈	Elbow Lengh	23
上腕周り	Upper arm	27
ひじ周り	Elbow	23
手首周り	Wrist	15
前腕周り	Lower arm	27
袖口周り（七分袖）	Cuff(Three-Quarter)	23

Figure 3. Customer measurements.

visualised on the screen. The customer selects materials, colours and structures, and such alternative styles as cardigan, sweater, slipover or other variations (Figures 4-6). As options are entered into the computer, they are converted directly into knitting information, eliminating the need for time-consuming programming of the knit CAD computer. The software automatically produces the knitting machine control instructions.

Although there is customer involvement in the design process, the outcome will not be a free fashion design, as the customer has a restricted range of options. After the client studies the product's image on the computer screen, further changes can be made. As in the case of the manual co-design process, at this point the customer may still opt not to buy the garment. If the purchase is made, a pre-payment received and the order is transmitted to the production unit.

Analyses

The simulation model and modelling method

Figure 4. Style selection in the Ordermade WholeGarment(r) system.

Figure 5. Sleeve length selection in the Ordermade WholeGarment(r) system.

Figure 6. Colour selection in the Ordermade WholeGarment(r) system.

A model can be understood as an artificial representation of an actual system. It should contain details, but no more than necessary to represent what it stands for. The discrete simulation we constructed employed the process-interaction method, whose basic function is to emulate the flow of an object through a system until it is either delayed, enters an activity, or has been completed. When the object is stopped, time is advanced to the next movement. The flow is a sequential representation of processes, waiting times, or other states that the object may attain in the system. Since each process and event in the model is simulated [28], the model represents the components of a system and their interactions.

Discrete-event models are time-based and their results are a product of the interactions of system components. In the case of the co-design concept, the model consists of the different components in the system and the values for these components. As such, it has seven processes, ranging from choice of style and material to the final attachments, as illustrated in Table 4. The simulations for the two co-design concepts were performed simultaneously. Each simulation represents 200 hours and was repeated 15 times. All process lead times for the final simulation are displayed in Table 4. The simulation begins when the co-design process between the company and the customer is initiated, and concludes at

Table 4. Lead times in the co-design process of knitted fashion garments.

Parameter	Manual co-design[a]			Ordermade WholeGarment co-design[a]		
	Min. process time[b]	Max. process time	Average process time	Min. process time[b]	Max. process time	Average process time
Style	7	15	11.0	2	6	4.0
Material	5	10	7.5	2	4	3.0
Neck type	4	8	6.0	2	4	3.0
Sleeve length	5	8	6.5	2	4	3.0
Size	5	20	12.5	5	20	12.5
Colour	5	15	10.0	2	4	3.0
Attach-ments	3	5	4.0	2	4	3.0
Total process time	34	81	57.5	21	58	39.5

a) All process times in minutes,
b) Times for customer co-design process exponentially distributed.

the point of sale (with the customer submitting an order and paying for the purchase). The aim of the model is to compare the two co-design concepts, while factors such as the number of customers entering the shop, the number of shop assistants involved in the transaction and the number of computer configurators in the store is varied. The simulation was produced by means of the AutoModTM system Version 11.2, a programme for building models and simulating detailed design, materials handling and manufacturing processes.

In-data for the simulation

The lead-time data are based on information from companies involved in the customisation of fashion products and our own experience with the Knit-on-Demand research project at the Swedish School of Textiles. The shop in the simulation is open to the public for nine hours a day. The 200 hours we have chosen for our simulation correspond to approximately one month of the shop's retail operations. An exponential distribution is used to model the arrival of customers at the shop at estimated interval of one minute. The probability that a client will start to customise a sweater is judged at 10%. It is also assumed that 50% of those who begin to co-design a garment will buy the product. In order to analyse the performance of the two co-design concepts, some key factors in each are changed in the simulations. In the Manual WholeGarment co-design concept, we have varied the number of shop assistants engaged in guiding clients in the personal design of a garment. In the Ordermade WholeGarment concept, the number of computers in the store is the variable. In both concepts, the number of shop assistants and configurator computers is set to vary from one to three in the different simulation runs. Input data for the simulation are displayed in Table 5.

Results of the simulation

To illustrate the results from the simulation, charts were made using the output data. The figures below summarise the results of the simulation. As an example of one of the fifteen simulations, Figure 7 examines the number of customised garments in Manual WholeGarment co-design compared with

Table 5. Input data for the simulation in AutoMod.

Input data	Value	Comments
Simulation time	200 hrs	The shop is open to the public for nine hours per day. These 200 hours correspond to approximately 1 month of the time the shop is open.
Customer shop entrance	every 1 minute	One new customer every 1 minute exponentially distributed.
Simulation repeated	15	The simulation is repeated 15 times.
Probability of a customer starting co-design	10%	There is a 10% probability that customers entering the store will begin to co-design a product. This is not the case with the Internet alternative. The aim here is to examine how many customers will customise a garment over a period 200 hours with a distribution of 1 minute.
Probability of a customer buying a product	50%	There is a 50% probability that customers who begin to co-design a product will purchase it.
Probability of a customer choosing to add attachment	50%	There is a 50% probability that customers who buy a product will also choose to add some kind of attachment.
Number of shop personnel	1,2,3,4,5	This value varies between 1 and 5.
Number of co-design systems	1,2,3,4,5	Number of co-design systems Ordermade WholeGarment® available in store.
Probability that a person in the shop staff is unavailable	10%	Unavailable for one day (9 hours).
Probability that a co-design system is unavailable	10%	Unavailable for one day (9 hours).
Number of shop personnel and co-design systems	5 and 5000	This factor is 5, except for the Internet alternative where the factor is 5000. The intention is to show the power of the Internet option.

products created with Ordermade WholeGarment co-design. For Manual WholeGarment, the result varies from 146 to 409 garments, depending on whether one, two or three shop assistants are available to assist with the co-design. Similarly, for Ordermade WholeGarment co-design the result varies between 259 and 794 customised products, depending on the availability of one, two or three computers available for customer use.

In Figure 8, we illustrate the situation when a store has five co-design computers available, rather than five salespeople. The result shows that co-design with a configurator is more efficient in terms of numbers of customised garments than the manual co-design option. At the end of 200 hours of simulation, the result was 800 customised products via a configurator and 700 with manual help from a shop assistant. To show the capacity attainable through a configurator and illustrate the difference between the alternative co-design concepts, we have projected the outcomes assuming five personnel in the shop, compared with 1000 configurators. Our intention is to show what happens if the configurator can be accessed through the Internet at a retailing company's web page.

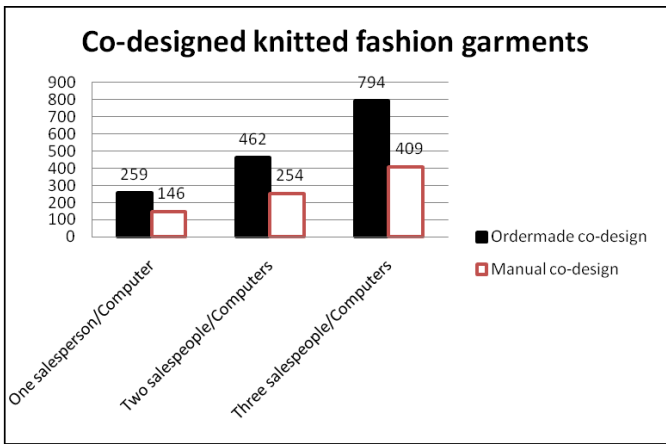


Figure 7. Total number of customised knitted fashion garments in one of the fifteen Manual WholeGarment and Ordermade WholeGarment simulations.

Figure 8. Total numbers of customised garments with five computers in the shop in Ordermade WholeGarment and five shop personnel in Manual WholeGarment.

Figure 9. Total number of customised garments designed via 1000 computers with Ordermade WholeGarment versus five personnel using Manual WholeGarment.

The results in Figure 9 show a significant difference between the two alternatives. The Ordermade WholeGarment system (in this case the Internet alternative) enables over 8000 products to be customised, compared with less than 1000 for Manual co-design. This rests, of course, on the great difference between the number of in-shop personnel and the almost unlimited access to configurators on the Internet (five versus 1000), and illustrates the vast possibilities the Internet option provides to retailers.

Comparison of the two co-design concepts

A problem for customisation of complete knitted garments has been the lack of a co-design interface between the company and the customer that would make the concept more efficient. The two concepts we have compared by means of simulations involve two approaches to customisation: the traditional manual co-design, Manual WholeGarment, a process not unlike olden times when the customer went to the tailor for new clothing. Since it involves interaction between the client and a skilled shop assistant, this type of co-design offers certain advantages, especially since it involves personal contact in a setting where guidance and advice can be given in designing the garment. Manual co-design should not be underestimated; many customers prefer it and feel more secure dealing with a shop assistant. Manual WholeGarment is well-suited for clothes in the higher price range. Stores that already have an established service-minded staff should consider it when deciding on the adoption of a customisation concept. The drawbacks of the Manual WholeGarment process are its low efficiency, since each customer requires individual attention from at least one shop assistant. Serving clients at one time requires a large staff to avoid queues, dissatisfied customers and lost sales.

Analysis of the two customisation concepts and the simulations indicates the strength of the Ordermade WholeGarment configurator tool. It allows customisation to be performed by the customer without requiring the presence of a shop assistant for each client. The results of the Automode simulations show that a configurator will enable more clients to customise a garment compared with the manual alternative. However, the simulations do not show a significantly better result for the configurator alternative, but co-design via computer by each customer allows for fewer store personnel and thus lower costs for the company. Co-design with Ordermade WholeGarment can also be perceived by many customers as a positive shopping experience, since it allows customers to fulfil their creative impulses and be a designer for one day. The positive effects of this concept are time savings in ordering, manufacturing, and delivery of the completed garment. Thus, Internet sales may present an opportunity for a company in the future and provide it with an efficient co-design system on its web page to serve many customers at the same time. One of the main drawbacks of any co-design system is that a client's measurements that must be taken by shop personnel, a time-consuming process, especially when many customers need to be served at the same time. One solution may be to let customers enter their own measurements directly into the co-design system, as many companies already do today. It may be difficult to do this accurately, and some people may resist the process altogether. The result of our analysis indicates that improvements might be done to make the co-design system more suitable for the fashion industry. First, we suggest that the co-design process be further developed to allow customers to input their measurements into the system directly. Second, the number of styles the system makes available to clients could be expanded. More styles, colours and materials would present an exciting shopping experience for prospective buyers. The latter, however, involves a balancing act, for as is well known in mass customisation, too many options can confuse the customer and result in a risk of lost sales. Finally, the sale and manufacture of mass customised clothing such as knitted garments depends on reducing the processes from customer demand to fulfilment of that demand so that the product can be delivered quickly. Especially important are those processes after the point of sale, when the customer (who is

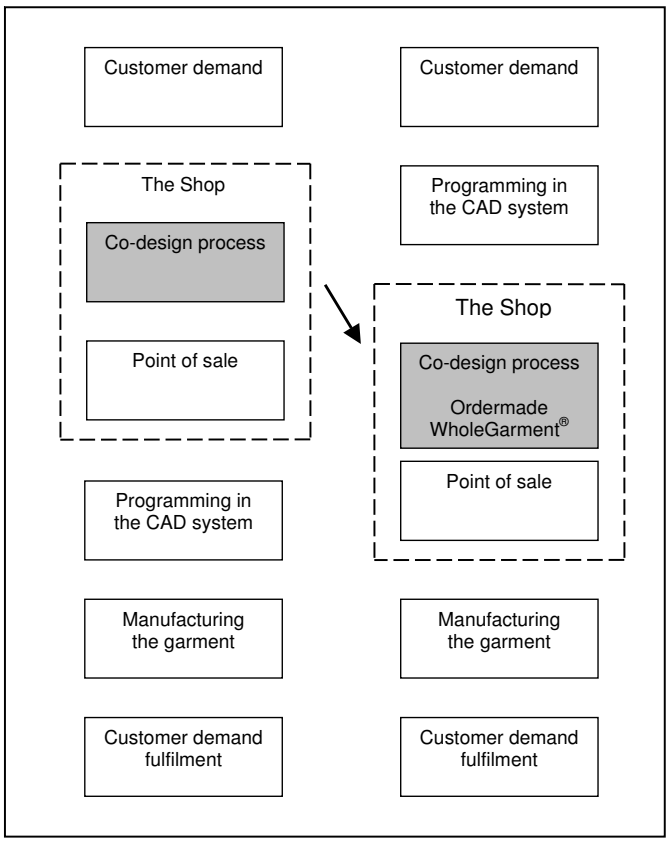


Figure 10. The concept with Ordermade WholeGarment(r) co-design tool.

accustomed to leaving a store with the purchased item) has paid for the garment and is eager to receive it. It is advantageous if manufacturing and delivery could be done rapidly in order to reduce waiting time for the customer. The development of the Ordermade WholeGarment system shows that it is possible to do the time-consuming programming of knitting machine design options before a client begins the customisation process. The result is increased efficiency in the production of a garment by expediting the co-design process and moving it one step closer to customer demand fulfilment, as illustrated in Figure 10.

Conclusion

A co-design tool for knitted fashion products has advantages that simplify the customisation process and reduce delivery time of the completed garment to the customer. Two main benefits of the system are identified in this paper. The first is that customers can do a considerable amount of customisation on their own, without requiring assistance from shop personnel. The second is that the customisation options in the co-design tool are pre-programmed, as is the control information for the knitting machine. Thus, when the customisation process has been completed the garment can be knitted without delay for time-consuming programming. Development of a configurator brings the process a step closer to mass production efficiency in the production of customised knitted garments.

The future of mass customisation of knitted garments looks bright for co-design systems of the kind we have considered. Perhaps stores like Factory Boutique Shima will one day offer clients the opportunity to design a product that is then knitted directly in the store and delivered to the customer within hours. We may see collaborations between fashion retailing companies with knowledge of market demand and a knitwear manufacturer for the development and production of co-designed products. The technology is already available that will encourage the growth of stores devoted to the mass customisation of fashion products with a minimum of help from shop staff.

Can we say that Ordermade WholeGarment(r) is successful? Thus far, it seems to have served to demonstrate how a computer-based system can be used for mass customisation of flat knitted products. Some aspects of the concept must be improved or altered if the idea is to spread to other retailers or knitting companies. For the system to take hold, there is a need to develop the co-design process to the point where customers do more of the customisation themselves. Internet sales may present the greatest opportunity for the future. With an efficient co-design system on a company's web site, the retailer's dream of providing personalised service to an almost unlimited number of clients with a minimum of employees may be very close to realisation.

There are also some limitations in the co-design tool Ordermade WholeGarment(r). The system is a multiple-choice system with, at this stage, not as many choices for the customer as would be desirable; this has to be further developed. Another issue is how to approach body measurements and garment fit in a simpler way. This activity is still a manual, time-consuming process that requires help from shop staff especially when many customers need to be served at the same time. Can the customers do this by themselves as shown by other fashion companies? However, this question must be studied and developed more in the future.

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