Method Article

Modeling mass customization level in apparel and textile design field

ABSTRACT

Mass customization is a new approach to manufacturing and providing services that is revolutionizing business and mainly in textile and apparel field.
How can we model the mass customization level? In this study we will present a review of the mass customization concept in textile and apparel field, and some key success factors such as modular product design.
It presents also a framework, aiming to develop the mass customization for textile and apparel industries, by reviewing and modeling the mass customization strategy by assessing the mass production level and the co-design experience level and by presenting some scales to classify the mass customization level.

Keywords: Modeling, Mass customization, textile, modular design, sustainability

1. INTRODUCTION

Individual customer needs are most obviously met in mass customization. This strategy is designed to specifically respond to two inherently contradictory competitive priorities - low price and high-customization. It is becoming more established in the textile industry as a response to ever-growing competition from low-cost economies and growth in demand for personalization.
Although the industries that practice mass customisation are not entirely successful in maintaining a low inventory and satisfying all their consumers, modeling and new advancements in manufacturing technology will allow mass customisation to be more ideal for both manufacturers and consumers. So, mass customization involves customers more than mass production.
For the example of textile and apparel industries, consumers and retailers help in the design process by selecting garment details, fabrics or size measurements for clothing items.
Some surveys tried to explore the links between mass customization and sustainability, such as Thomas and al. that concluded that there are indeed many elements of mass customization which can influence the environmental sustainability of a product if it is compared to a similar mass produced product [12].
Finally to implement mass customization in apparel industries we need to review and model the customization process and to develop appropriate models and scales for assessing “mass customization” aspects of the strategy.

2. MATERIAL

2.1 Review of mass Customization’s concept

The concept of mass Customization was first proposed by Stan Davis in 1989. Davis studied Time, Space and Mass and mentioned about the business strategy that focused on quick response that was the origin of the concept "Any time and Any Place/Anywhere". Later, this concept was continued by B. Joseph Pine [1] he recommended a concept of perceiving two bipolar things between the large amount of production and the response to particular individuals.
Piller [2] defines mass customization as, "Customer co-design process of products and services, which meet the needs of each individual customer with regard to certain product features. All operations are performed within a fixed solution space, characterized by stable but still flexible and responsive processes. As a result, the costs associated with customization allow for a price level that does not imply a switch in an upper market Segment."
Tseng and Jiao [1] define mass customization as, "technologies and systems that deliver goods and services that meet individual customer's needs with near mass production efficiencies."
Pine introduces a model called "Feedback Loop" [1] In effect the chain bends around to become a loop with customers as integral part of it, creating and becoming prosumers, producers and consumers at the same time. Within this loop manufacturers and prosumers communicate interactively.
Kumar in 2004, presents the mass customization process in different steps as follow [14]:

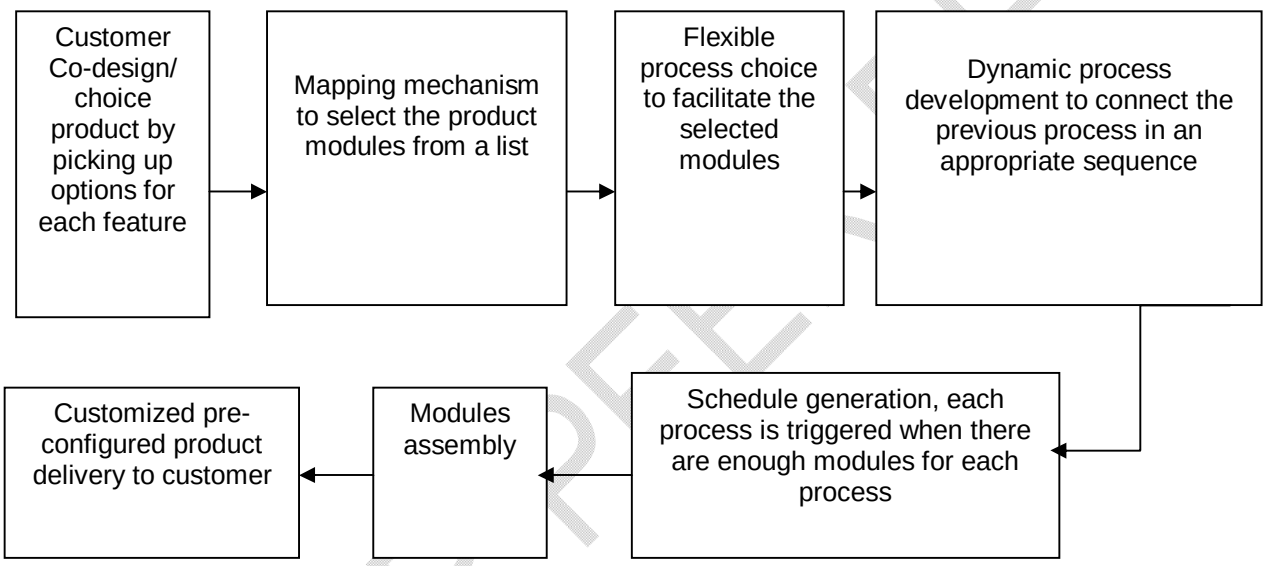

Fig.1 process for mass customization starting from customer co-design until the delivery of the customized product works [14]

2.2 Mass Customisation in textile and apparel industries

One of the first industry sectors to bring mass customisation to the end user is the textile and apparel industry.
Mass customisation can be seen as a hybrid of mass production and customisation [3]. This system, like mass production, serves a large market with low cost products. By applying additional technology, the manufacturer is able to respond to consumer drives for custom garments. In order to implement mass customisations, it is necessary to implement technologies such as a flexible manufacturing system, computer-integrated manufacturing, computer-aided design or advanced computer technology [4]

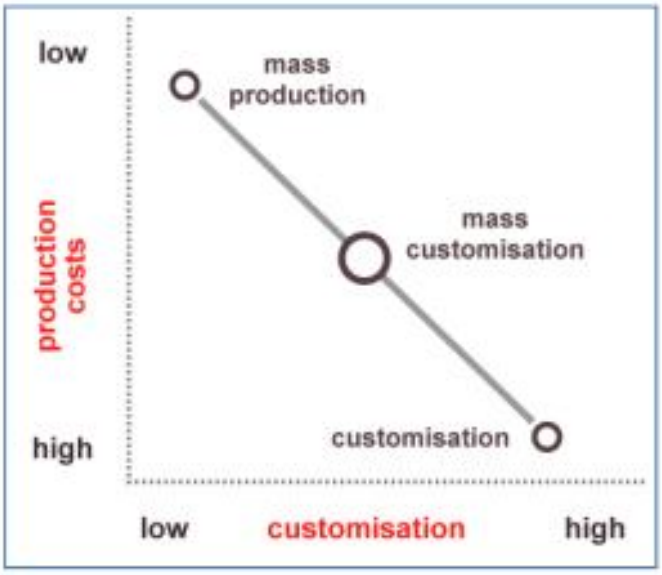

Fig. 2. Mass customization : a hybrid of mass production and customisation [5]

Mass Customisation for apparel can be positioned into three main categories including personalization, fit and design. For personalization, products are customized for consumer individual needs. Personalized body measurements and specifications are supplied to the manufacturing process to be individually made to meet the customer selection, e. g. color, fabric, construction, accessories, thread,…

According to Anderson-Connell, Brannon, Ulrich, and Marshall [5], consumer interests in customizing apparel include changing design options and personal fit with the aid of well-trained assistant which they called co-design. They found fit to be a critical issue in apparel mass customization. Anderson-Connell, Brannon, Ulrich, Marshall, and Staples created a model of mass customization for the apparel industry

Lee and Chen [4] described how apparel industries practice mass customization based on the concept of mass customisation defined by Pine [1]. They discussed technologies such as “smart card”, “body scanner”, and information collection. The precise measurements of individual consumers are required to customize apparel product and a consumer is able to be measured by hand, by body scanner, or by video camera. Then, these measurements are extended into the system which consequently adjusts the size of matching points on the pattern prototype [4]. They explained that apparel found new niche markets for the made-to-measure garment and mass customization became a broad trend for apparel industry production and retail [4].

Furthermore, mass customization requires customer interaction and indeed, customer co-design at the time of ordering the product. Thus, a product produced with the mass customization strategy in place commands a much higher customer satisfaction and, in many cases, happy customers act as ambassadors promoting the company product and practices. We conclude that mass customization improves a firm’s performance on all five priorities—price, quality, flexibility, delivery, and service—simultaneously.

Lee and Chen [4] described how apparel industries practice mass customization based on the concept of mass customisation defined by Pine [6]. Lee and Chen [4], explained that apparel industries with the manufacturing concepts such “Just-in –Time” or “Quick Response” found new niche markets for the made-to-measure garment and mass customization became a broad trend for apparel industry production and retail.They presented a model explaining the effect of mass customization on the apparel industry. In clothing companies, mass customization begins in retail store where a line ready-to-wear is provided along with mass customization services [4].

2.2 Options process developed in customized textile product

Fiore, Lee, Kunz, and Campbell [7] described two important options in mass customization are body scanning for better fit and co-design for a unique design. In co-design the customer, generally with the aid of CAD technology and/or professional assistance, compiles an individualized product design from a company's style, fabric, color, surface design and size alternatives [7].
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In apparel industries, the customer also has the opportunity to choose the garment design and any style changes from a menu of offerings, along with the fabric and colour. Design simulation and 3D colour mapping all come into play here since they allow the customer to view a virtual copy of the garment before the order is placed.
Besides, testing styles and fabrics with retail customers during the pre-season provides valuable information used to plan (or mass customize) production. Basic styles and styles identified by retailers for which an apparel producer is certain to get orders can be produced early in the season.
The digital information and new technology in the process of manufacturing will develop customized apparel with four options : "expanded selection/search", "design option", "co-design", and "total custom". In the "expanded search", a customer is able to access various manufacturers' product lines through intelligent search capabilities. In the "design option", the customer is able select from manufacturer/retailer's designs, sizing, style options, style details, color and fabric. "Co-design" offers additional personal fit through the ad design manager, based on the "design option choices". Finally in "Total Custom", the customer communicates his or her own designs to manufacturers or retailers in a digital format [8]
Anderson et al. [5] present a model of the effects of mass customisation in the apparel industry, they indicated that digital information and new technology in the process of manufacturing will develop customised apparel with the four previous options.

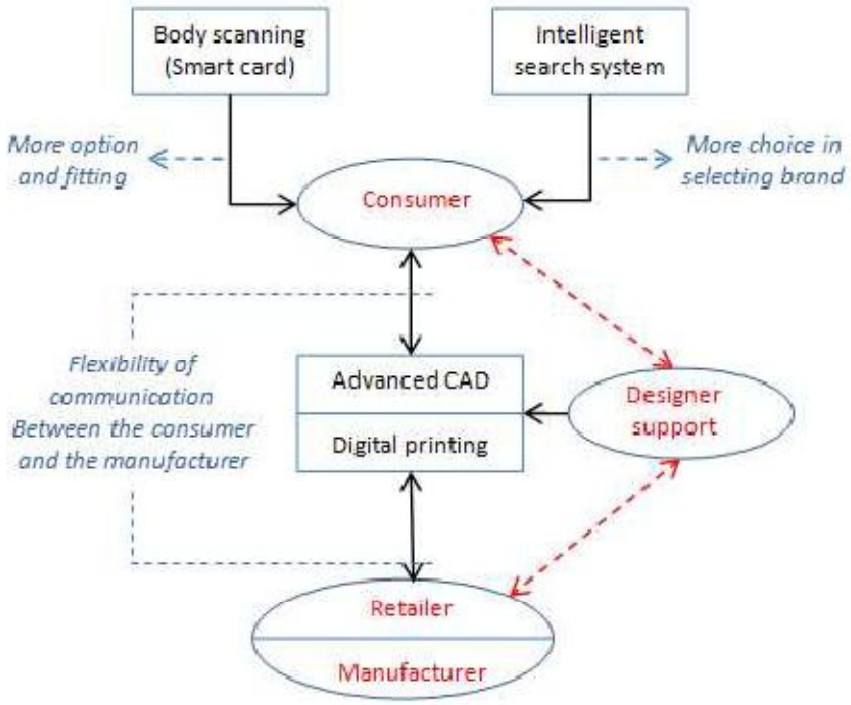

Fig. 3. Possible effects of mass customisation in the apparel industry Anderson et al. [5]

In the production process of apparel industries, mass customization strategies can be used at any of the six following stages.

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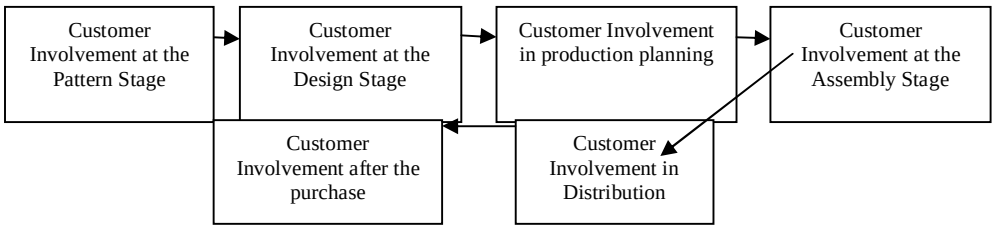

Fig. 4. Customer involvement in the stage of the apparel production process

Mass customization allows the consumer to modify a company product line to meet individualized design tastes or fit requirements.
Finally, post-purchase adjustments can also be built into the product for customers to do it themselves. Higher tech suggests a future for creative post-purchase adjustments that could increase a firm's competitiveness. So, there would be higher degree of mass customization involved like pocket type, buttons type, designing parameters and new fashion styles.
Finally, many options can be involved in the mass customization for apparel industries and two mains factor affecting mass customization, which are the co-design experience and the mass production will be described, reviewed and assessed in the following parts.

2.3 The co-design experience

Mass customization requires an intense dialogue and collaboration between the company and the customer. Mass customization is characterized by the co-design experience. This is an interaction between the individual and the product during the design process allowing foster the development of solutions for consumers. According to Watcharapanyawong and al. [9], the co-design: development of a product or service with the involvement of the customer or end user in the design process.
Mass customization has advantages for both business and consumers by integrating co-design experience as a factor of innovation. Mass customization has advantages for both the brand and the consumer. The consumer pays the value of a product customized, and also to co-design experience. »
The experience of co-design allows the user to participate in the creation of new models, control the design phase and check predefined range by the brand with the aim to develop creativity and promote primordially use and the attitude of the consumer. The interest to undertake a co-design approach is to take into account all the circumstances of practice for better anticipate the end use before the stage of technical development.
This is a type of Mass Customization that emphasizes on Co-design sometimes called Customer Integration, aiming at adding values, exchanging or even problem solving for particular customers. The roles of relationship between firms and consumers belong to the companies themselves [5] . Every section of organizations has to work together in order to help design a model, manage the production process and take responsibilities.

3. MASS PRODUCTION

The mass principle in the concept of mass customization then designates the mode of production. Indeed, it is an industrial and organizational strategy of differentiation by placing on the market of unique patterns, serially produced. Mass customization takes advantage of low unit production costs that characterizes mass production, while adopting a more flexible approach to individual customization.
The mass customization need to respect cost, quality, and a manufacturing time aligned to those observed in a mass production.
We will try to assess the mass production and the co-design experience to assess the mass customization level.

3.1 Assessment of the level of mass customization

In order to assess the level of mass customization, we will propose a method to evaluate the following two variables: the level of mass production and the level of co-design experience.

3.1.1 Assessment of mass production level

In order to assess the production's process of the customized textile product, we propose to classify the mass production level into the following three main types:

- First Level, 100% completely mass production when we have all process in series
- Second level, middle mass production level when we have production process including some customized tasks
- Third Level, low mass production level when production process with several customized tasks

So the level of mass production decreases as the number of customized operations increases. We propose a scale (Scale 1) ranging from 0 to 1, which shows the level of mass production (I_{PM}) as follows:

- If the mode of production in series, with several custom tasks, so I_{PM} tends to 0
- If the mode of production is in series, including some custom tasks so I_{PM} tends to 0.5
- If the mode of production is completely in series, so $I_{PM} = 1$

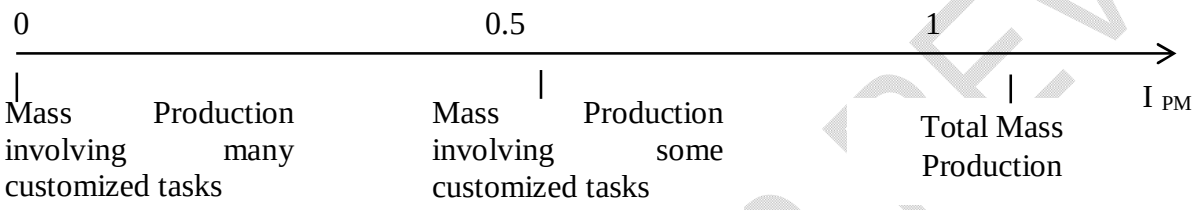

Fig. 5. Scale 1: mass production level in a mass customization experience

3.1.2 Assessment of the level of co-design experience

The co-design experience depends on the customizations options defined by the company. These customization options vary depending on the product and customization means (online customization or manual). Therefore, we propose below a conceptual map, which defines possible customization options in apparel industries.

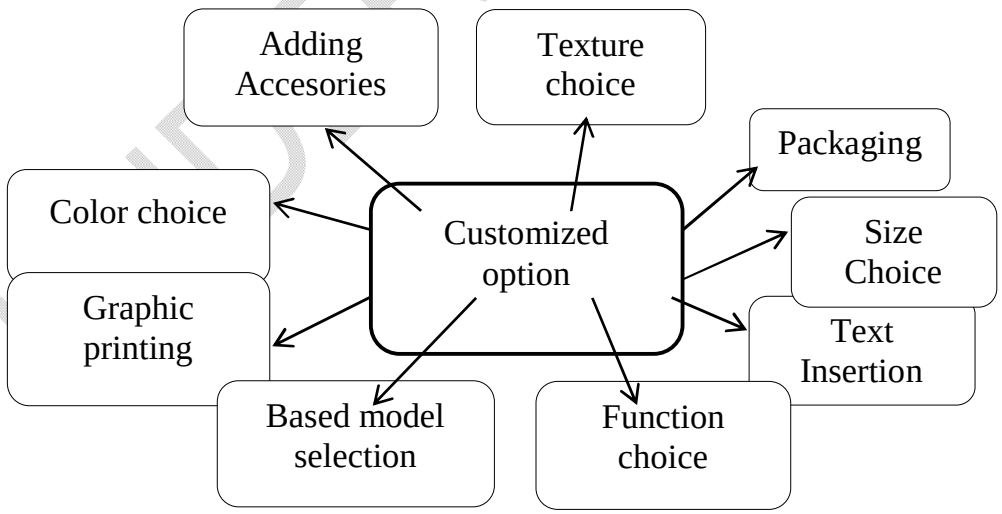

Fig.6. Conceptual map with diverse customization options

To assess the level of co-design experience we can propose a scale ($I_{co\text{-}design}$) according to the number of customization options (Scale 2).

- If the customization options are limited, so $I_{co\text{-}design}$ tends to 0
- If the customization options are diverse, so $I_{co\text{-}design}$ tends to 1

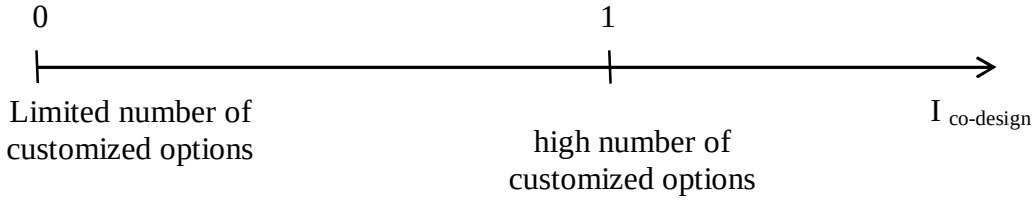

Fig. 7. Scale 2: Level of co-design experience

Therefore, if the number of customization options increases, the level of co-design experience also increases.

3.1.3 Assessment of the level of mass customization

Having defined a scale of the mass production level and an assessment of the level of co-design experience, we then deduce an overview of the level of mass customization, shown in the following figure, combining the two following variables: the level of co-design experience (x-axis) and the level of mass production (y-axis).

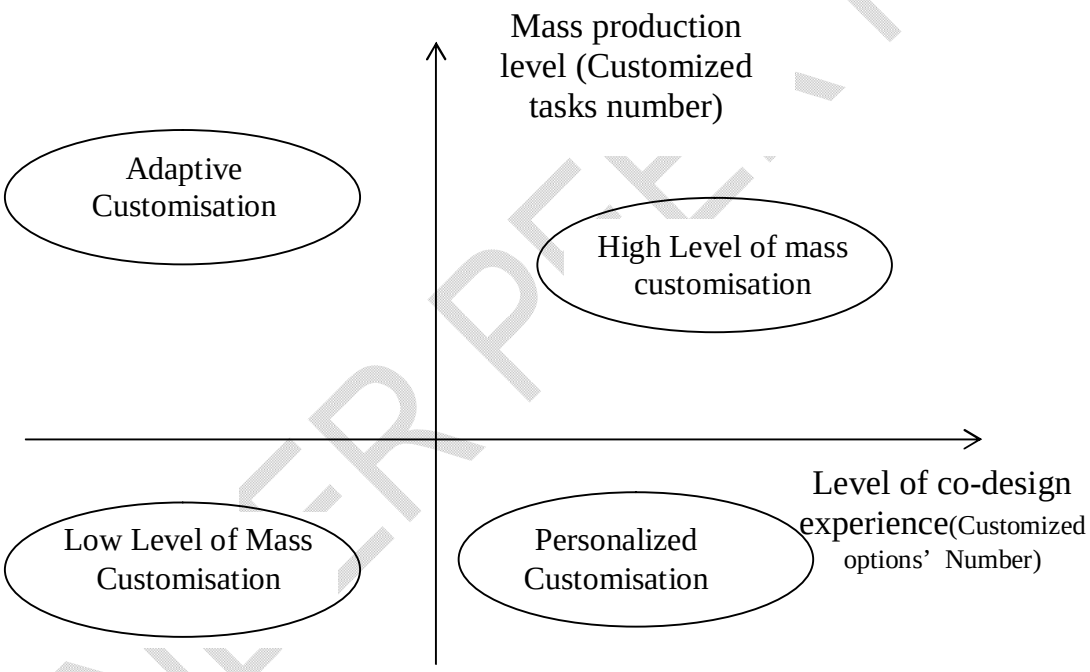

Figure 8. The level of mass customization

From the previous Figure, we can define different situation of mass customization according to the level of mass production and the level of co-design experience.

First we start with the first case: When the level of co-design experience increases and the level of mass production decrease, in this case we talk about personalized customization. Indeed, increased customization options, such as inserting images and texts, mass production level is low and product cost increases consequently.

For the adaptive customization, the situation is achieved when the level of mass production increases and the number of customization options decreases. In this situation, the co-design experience is limited by the combination of the various components of the product.
The third case, we see a customization that tends towards a high level. Thus, in order to converge to a high level of mass customization we need to increase both the level of mass production and the level of co-design experience.
The last case is observed when mass production and co-design experience levels are low, so we cannot talk about mass customization.
The increase in the production level mass is achievable through the restriction custom tasks performed, in order to benefit fully from a production series. Thus, the increase in the level of co-design experience translates into increased customization options
However, and in order to satisfy a wide social spectrum, we propose to combine the internet customization, the choice we offer several customization options with manual customization. In this approach, we propose to divide the co-design experience into two parts: the first part is the one with mass production, hence the choice of color, texture, function and design will made by Web site. The second part, with customized tasks, we propose to set them manually by providing the necessary tools to perform these tasks (product kit).
Then, we propose to decompose the product of elementary modules resulting in different designs. The advantage of this decomposition process is beneficial both for the company and the customer.

3.2 Modularity and mass customization assessment

A manufacturing process that responds to customers' needs in the form of Mass Customization puts an emphasis on a variety of responses while all the prices are still maintained. As a result, most organizations are attempting to find out a solution that can be used as a perfect production system, which is flexible, and its production investment is as equal as the process of Mass Production, for example, Modularity system for Mass Customization proposed by J.H. Mikkola [10]. This systematic model also supported Mass Production as in the system, the production processes were classified into stages from the selection of raw materials until the combination of the whole products.
Importantly, a designer has to clearly comprehend the complexity of each production stage, sometimes called "Modularization Function" so that the implementation of the production process could be as efficient as possible.
Modularity in product design supported by stable, flexible, and modular processes is at the heart of a mass customization strategy for most companies. Such companies are those that sell a multi-feature, multi-functional product. Modularity allows calibration of the level of customization of the entire product with respect to each product feature/function.
Modularity works can create a customized product on one hand and mass production efficiencies on the other.
It is essential that modularity in product design will be integral to a mass customization strategy, especially for multi-feature, multi-functional products.
A modular design of the product will have separate components for each function. Therefore, a customer could configure his product using any one of the options available for each function feature. In addition there may be a standard product that would be common in all variants. This means the customer will pick up some options available to configure his product.
The mass customizations strategy allows efficiencies of mass production through distribution of demand over a few levels/options while allows high level of customization through modular design of products.
In this context, we can define at least three types of mass customizers depending on the modularity:

- 100% customization level and, therefore, have infinite modularity. These customizers thrive on their advanced technology
- Middle mass customization through modularity due to the fact that their products are multi-featured, multi-functional, finite modularity,
- Early mass customizers who have not yet gotten into modularity [1].

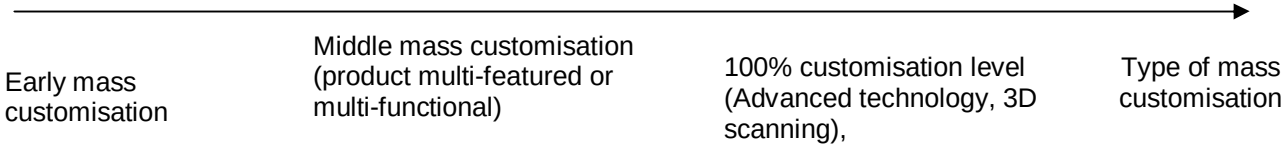

Fig.9. Type of mass customization according to modularity

Finally, technology remains a key to developing a profitable supply chain capable of bringing mass customization to consumers, the type of mass customization according to the number of modules depends also on the advanced used technology, such us 3D scanning for 100% customization level.
Finally, companies can take different approaches to mass customisation. A basic range of products can be changed to meet individual needs, as is the case for made to measure garments, where mass customisation is treated as change in development. The other extreme is to offer a modular product range, which is configured to meet customer needs.

4. CONCLUSION

There are new designs coming up every day in apparels. With increasing customer base, the number of designs would multiply. Therefore, garment industries actors had to have a flexible manufacturing system which will take care of these parameters such as mass customization.
We conclude that mass customization strategy is very attractive where economies of scale are used as leverage for reducing unit product cost. In other words, the true strategic and financial potential of mass customization strategy is available in those scenarios where technologies needed for 100% customization are not available or are prohibitively expensive.
And, a successful application of mass customization strategy, when that is the case, would inevitably require modularity of product as an essential condition.
Mass customization strategy offers across the board improvements in product differentiation so that a firm can compete better on price, quality, flexibility, delivery, and service. We suggested that mass customization strategy offers improved quality and agility through the production system design that was modular.
Our study on the development of mass customization in apparel industries was done on different part. The first part is devoted to the study of mass customization concept, we have presented some factor affecting mass customization level like mass production level and co-design experience level. We proposed some scale related to the assessment of mass customization.
The effects of mass customization benefit the consumer, retailer and the manufacturer
Finally, customer co-design is the most fundamental aspect of mass customization, which differentiates it from other customization strategies.
We believe that despite huge potential of the mass customization strategy to enhance a firm's competitiveness, the research on the subject much remains to be done.

REFERENCES

1. Pine, B. J. II (1993a), "Mass Customizing Products and Services," Planning Review, Vol. 21, No. 4, pp. 6–14.
2. Piller Piller, F. T. (2003), 'What is Mass Customization? A Focused View on the Term,' Mass Customization News, Vol. 6, No. 1, pp. 2–4 (2003).

3. Feldbrugge E. , (2010), '3D body scanning in the clothing industry', the Amsterdam Fashion Institute (AMFI) 500516 –June 2010

4. Lee, S.E. and Chen, J.C. (1999), "Mass-customisation methodology for an apparel industry with a future". Journal of Industrial Technology, Volume 16, Number 1 (November), p. 2-8.

5. Anderson-Connell, L., J., Brannon, E. L., Ulrich, and P. V., Marshall T, and Staples N. J., (1998) Discovering the process of Mas customization : A paradigm shift for competitive manufacturing : National Research Center Briefs.

6. Piller, F. T., (2004), 'Mass Customization: Reflections on the State of the Concept,' International Journal of Flexible Manufacturing Systems, Vol. 16, No. 4, pp. 313–334.

7. Provenmodels, (2010) 'Defining mass customisation', www.provenmodels.com/596/masscustomisation/b.-joseph-pine-ii/ (21 April 2010)

8. Pine B. , II. (1993b), 'Mass customization: The new frontier in Business Competition'. Boston, MA02163: Havard Business School Publishing.

9. Fiore A. M., Lee S., Kunz G., Campbell J.R. (2001) 'Relationships between optimum stimulation level and willingness to use mass customisation options', Journal of Fashion Marketing and Management: An International Journal, Vol. 5 Iss: 2, pp.99 – 107

10. Jiao, J. and Tseng, M. M. (2000), 'Fundamentals of Product Family Architecture,' Integrated Manufacturing Systems, Vol. 11, No. 7, pp. 469–483.

11. Ulrich, P.V., Anderson-Connell, L., J., and Wu. W. (2003) Consumer co-design of apparel for mas customization. Journal of fashion Marketing and Management, 7 (4), 398-412.

12. Watcharapanyawong K., Sirisoponsilp S., Sophatsathit P. (2011), A Model of Mass Customization for Engineering Production System Development in Textile and Apparel Industries in Thailand, Systems Engineering Procedia 2, 382 – 397 2011 Published by Elsevier B.V. doi:10.1016/j.sepro.2011.10.052

13. Mikkola , J H . (2007), 'Management of Product Architecture Modularity for Mass Customization: Modeling and Theoretical Considerations'. IEEE Transactions on Engineering Management. New York: Feb Vol. 54, 2007.

14. Kumar A., (2004), 'Mass Customization: Metrics and Modularity', The International Journal of Flexible Manufacturing Systems, 16, 287–311, 2004 2005 Springer Science + Business Media, Inc. Manufactured in The Netherlands.

15. Thomas Ditlev Brunø, Kjeld Nielsen, Stig Brink Taps, and Kaj A. Jørgensen, Sustainability Evaluation of Mass Customization, V. Prabhu, M. Taisch, and D. Kiritsis (Eds.): APMS 2013, Part I, IFIP AICT 414, pp. 175–182, 2013. © IFIP International Federation for Information Processing 2013.