Hindawi
Mathematical Problems in Engineering
Volume 2022, Article ID 8734113, 8 pages
https://doi.org/10.1155/2022/8734113

Research Article

Application of Digital Technology to the Construction of the Fashion Design System under Mass Customization Mode

Xiaoyu Meng

Art College of Dongguk University, Dongguk University, Seoul 100011, Republic of Korea

Correspondence should be addressed to Xiaoyu Meng; erer@st.btbu.edu.cn

Received 5 January 2022; Revised 23 February 2022; Accepted 28 February 2022; Published 2 June 2022

Academic Editor: Dost Muhammad Khan

The study aims to improve the efficiency of clothing production and make the clothing design diversified and flexible. First, the design under the mass customization mode (MCM) based on digital technology (DT) is studied. Second, the development direction of clothing production under MCM is discussed through the analysis of the current situation of clothing production. Finally, the prospect of clothing design and production under MCM is predicted. The results show that the application of DT to clothing design under MCM can make the style change flexibly in the design as needed and effectively improve the efficiency of clothing production. With the help of DT, manufacturing enterprises will increase their investment in clothing production under MCM in the next 5 years, and the consumption rate of consumers for the clothes under MCM will also increase sharply. And the profit made under the mode will be four times as that of the previous. This study provides a reference for the development of MCM and helps understand the MCM further. Finally, the simulation results of clothing design show that the clothing designed following DT is faster, more flexible, and diversified, and DT dominates the production scale of clothing production.

1. Introduction

The mass customization mode (MCM) refers to the organic integration of mass production, technological process, and enterprise management. Through its flexible production mode and rapid response ability, the production under MCM can provide more diversified products into the market. And enterprises can establish their competitive advantage and create more economic value following the mode [1, 2]. The production under MCM is to design products flexibly and manufacture them rapidly and on a large scale. It enables consumers to virtually experience the products designed for them and improves the production efficiency and enterprises and use efficiency of products. With the development of MCM in other industries, clothing manufacturers begin to take the experience from the manufacturers of automobiles computers. Different from other enterprises, the key to the transformation of the clothing production from the traditional into MCM is mainly the transformation in the stages of clothing design and process. Since these stages cover the unique features in the clothing industry, it is very important to study the mode in the stage of clothing design [3].

With the progress of times, personalization becomes popular in all walks of life, that is, when consumers choose and use products, they will give priority to choosing products different from others to highlight their personality. Customized and limited products can meet such needs because they are designed according to the requirements and preferences of consumers and highlight the personality of the consumer [4]. This is why they are extremely luxurious. In the clothing industry, customized products have become the preferred products of consumers [5]. When customized products are more and more popular, the traditional manual customization mode cannot meet mass production of customized products. However, purchasing and pursuing customized and limited products have become an inevitable trend of the times [6]. In the reform process of mass production of customized products, digital technology (DT) gradually attracts the attention of scholars because the use of DT to produce customized products can better highlight the personality display consumers' personality and achieve mass

production [7]. With its support, the production mode of clothing enterprises gradually changes from the traditional handmade mode and fixed machinery production mode to MCM. In this mode, enterprises invest more in producing more customized products and make MCM continue to grow and improve further. And consumers also actively respond to the change of the market, and the turnover of the clothes under MCM also provides financial support for the change of the production mode and promotes the change of the clothing production mode [8]. As the main technical support, DT can ensure that every link operates smoothly in the production of clothing. It is found that MCM based on DT can save manpower and time and play an important role in the selection of clothing materials, clothing styles, clothing colors, and clothing pattern shaping [9]. Compared with the traditional handmade and fixed machinery production mode, the application of DT to clothing design can satisfy the consumer and accelerate the mass production of clothing, which is a great breakthrough in the field of clothing production [10].

The current production mode of the clothing industry is analyzed to provide data for the transformation of the production mode of enterprises. And the simulation experiment of clothing design by DT gives technical support for the transformation of clothing design under MCM and the improvement of the clothing production mode of enterprises and ensures the steady development of the consumer market.

2. Materials and Methods

In the handmade era, almost all products are produced by hand. There needs a lot of manpower in this production mode, but the production speed is slow, making demand surpass supply [11]. Although handmade products can be designed flexibly, but the product quality and production process may not meet the standard. In this case, the handmade production mode needs to be changed and mechanical production is born. Mechanical production can produce large-scale products according to production standards to meet market demand [12]. As time goes by, various industries begin to continuously innovate their production mode to make themselves more competitive. Under such circumstance, the production mode of consumers' customization of personalized products is gradually formed [13]. Figure 1 shows the comparison of the design and production under different modes.

Figure 1 shows that the design and production under MCM is superior to other modes in all aspects. It can quickly supply enough products to the target market and achieve personalized design through flexible changes according to consumers. Under this mode, high-speed production machinery is required and its normal operation should be ensured. It is obvious that traditional fixed machinery is not applicable, and the reform of the traditional machinery is imperative.

2.1. Research Status. The transformation from the traditional production mode to MCM needs to be gradually carried out

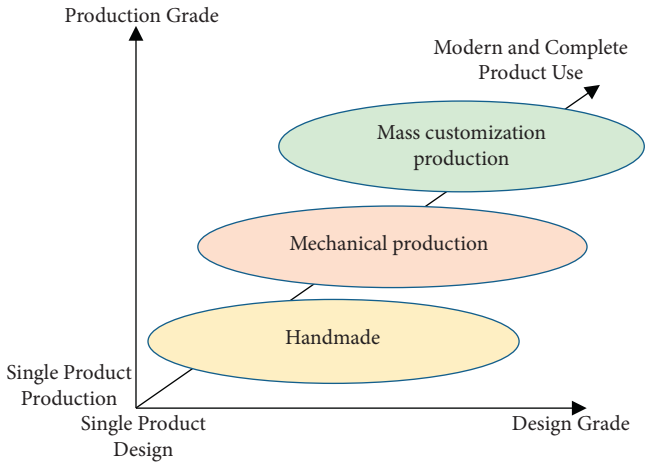

Figure 1: The comparison of the design and production under different modes.

and constantly improved. Here is some research about it. Xu et al. pointed out that MCM came into being as a new production mode, and the mass production mode with customer experience as the main feature is gradually replaced by MCM with mass customization as the mainstream production mode. And there are some enterprises whose transformation of the production mode is successful [14]. Kovacs et al. [15] believe that, with the formation of the consumer's market, MCM is employed widely by enterprises, and time-based competition is the key to maintaining sustainable their competitive advantage. He also argued that general parts lower the diversity of components of enterprise and advocated that enterprises should provide diversified products to the market in response to the needs of the market. Finally, he recommended that reasonable control of lead times can achieve safe stock, reduce the risks of out-of-stock, and improve the service levels and competitiveness of enterprises [1]. Rocha and Miron uttered that many enterprises produced their products under MCM based on DT. However, not all enterprises could get the expected effect, and many enterprises encountered many problems in the implementation process [16]. Siderska and Jadaan pointed out that, with the rapid development of information technology (IT), the new production mode based on cloud manufacturing becomes the development direction of China's manufacturing industries. The Cloud manufacturing mode provides a new idea to solve the problems of resource volume of enterprises. It is believed that mass customization represents another advanced manufacturing mode in today's manufacturing field, and the emergence of cloud manufacturing also provides technical support for rapid and accurate production of mass customization [17]. Fathi and Ghobakhloo mentioned that the existing clothing production mode is difficult to process large quantities and multivarieties of the market. The traditional single-volume production mode has the shortcomings of a long production cycle and high cost. Therefore, MCM becomes a new trend in clothing production [18]. Liu and Yao argued that MCM can show the personality of consumers according to their needs, improve production efficiency, and cut the cost.

Therefore, it conforms to the developing trend of the market, and the transformation into MCM also needs the help of IT [19]. And DT, as a new technology, can play a leading role in the transformation of the production mode.

2.2. Research Theories. After the product to be designed is determined, the ideas of consumers are simulated first, which may help to acquire some ideas in the product design in consumers' shoes. Second, the model of the product to be designed is determined according to the basic ideas. Finally, various features are added through the model. Figure 2 shows the design and production of the consumer's products.

Figure 2 shows that the servicemen of enterprises will be contacted through the cloud communication device when a consumer needs a service. The consumers inform the serviceman their needs and provide their basic information, and the serviceman delivers the relevant information to the designer through customer service. The designer makes the basic models on software according to the information provided, and the designed models are given to the consumer for selection. If the consumer feels that the models are acceptable, the serviceman will purchase the raw materials through the basic needs of the consumer, and the designer will make a scheme and pass it to the production factory combined with the material. The factory produces the product through the intelligent production mode. Finally, the produced products are delivered to consumers. Otherwise, the designer can continue to provide the models to the serviceman again and again until the consumer is satisfied with the model. And the designer should give the message of the requirements to the production plant for subsequent processes [20]. In the whole production process, consumers and employees do not need to communicate in person, and they can communicate through the cloud. This production mode simplifies the production processes and offers consumers many optional opportunities [21]. Figure 3 shows the process of customizing clothing for consumers.

Figure 3 shows that customization is conducted from the selection of raw materials to the output style. When the material is dyed, consumers can choose colors they prefer, and they can also choose personalized cutting styles. In the whole process of clothing making, consumers can express their opinions at any time, and clothes are made according to their preferences to ensure that the produced clothes are fit for consumers.

2.3. Research Methods. Cloud-based information collection and simulation design are used. First, the status quo of MCM is investigated. This is achieved by data collection and analysis of the consumption levels of consumers and the production mode of enterprises through the cloud. Then, a product design model is implemented by combining DT with the consumption levels of consumers and the production mode of enterprises. Through data collection by the cloud, the collected data are calculated through the correlation coefficient equation:

$$x = \sum_{i=0}^{n} \sqrt{\frac{(X - \overline{X})^2}{n-1}}, \tag{1}$$

$$x = \sum_{i=0}^{n} \frac{(X - \overline{X})^2}{n-1}, \tag{2}$$

$$x = \sum_{i=0}^{n} \frac{(X - \overline{X})(X - \overline{X})}{n-1}. \tag{3}$$

The standard deviation, variance, and covariance of the collected data are calculated by equations (1)–(3), in which X is the collected data and n is the total number of collected data. Then, the collected data are standardized, that is, the collected data are grouped and compared, and the curves of the two groups of data are analyzed [22]. The data are divided into and two groups, namely, group X and group Y to calculate their standard deviation, variance, and covariance based on the following equation:

$$\rho_{XY} = \frac{\mathrm{Cov}(X,Y)}{\sqrt{D(X)}\sqrt{D(Y)}} = \frac{E[(X - E(X))(Y - E(Y))]}{\sqrt{D(X)}\sqrt{D(Y)}}, \tag{4}$$

where Cov represents the covariance of the data, D represents their standard deviation, and E represent their variance. The area and curve distribution $\mathrm{dist}(X,Y) = 1 - \rho_{XY}$ of the groups of data are calculated, and the current situation of clothing production under MCM is analyzed [23].

DT plays an important role in clothing design. Compared with the traditional measurement and production process, the clothing design based on DT is more accurate and fast. In the process of clothing design and production, DT is used to estimate the figures of consumers and the value of each dimension and determine the size of clothes and their style. And the specific style in the design software can be adjusted according to the opinions of consumers freely. Figure 4 shows the initial interface for clothing design.

Figure 4 shows that the body shape, hobbies, and opinions of consumers can be considered in the clothing design, and the design includes the style, color, pattern, and size of clothes. Then, the designed model is sent to the consumer for selection, and any modification can be made on the basis of the original version as required until the consumer is satisfied. Then, the designed styles are transmitted to the factory for production. In the production process, the parameters are set in the mechanical system for accurate production according to the specific drawings provided by the designer, and the number of clothes can be set according to the specific needs in the production process.

3. Applications of TD to Clothing Design

3.1. Application Status. In the research process, the current situation of MCM and the traditional production mode is also collected and analyzed. Figure 5 shows the production scale under different production modes in recent 5 years.

Figure 5 shows that, in the past five years, the traditional production mode, mechanical fixed production mode, and

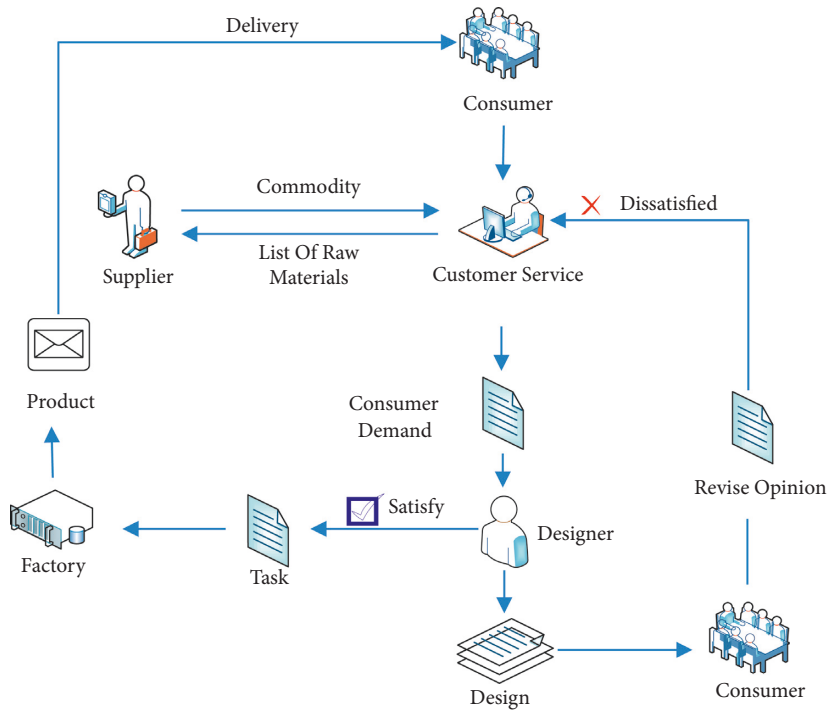

Figure 2: Design and production of the consumer's products.

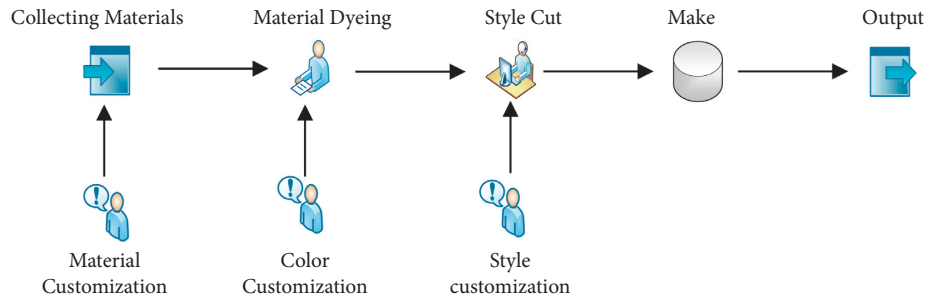

Figure 3: Process of customizing clothing.

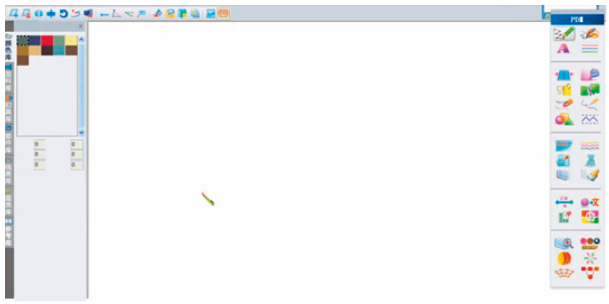

Figure 4: Initial interface of clothing design.

MCM have been carried out in the clothing production industry. However, the data show that the investment in the production under MCM is larger than traditional production mode and mechanical fixed production mode. Since 2016, the investment under MCM exceeds greatly over that of the traditional manual production and fixed machinery production mode. From 2017 to 2019, there was a slight decline, but it began to rise in 2020. Compared with the investment in 2017, the difference among them is not large. This shows that the development of MCM will continue to rise steadily. MCM saves manpower and simplifies production procedures in the production. The clothes produced under MCM still occupy the largest market share in the market, which proves that MCM is promising. However, it still needs continuous improvement to successfully achieve the sustainable development of the production mode of the clothing industry. DT can save costs and improve the profits of products. For consumers, purchasing customized clothes can release their personality and make them feel unique.

The transformation of production mode requires the transformation of the production modes of enterprises, and the transformation of the consumption modes in the entire market. And the continuous development of a product needs the recognition of consumers. Therefore, in the transformation of production mode, consumers are required to

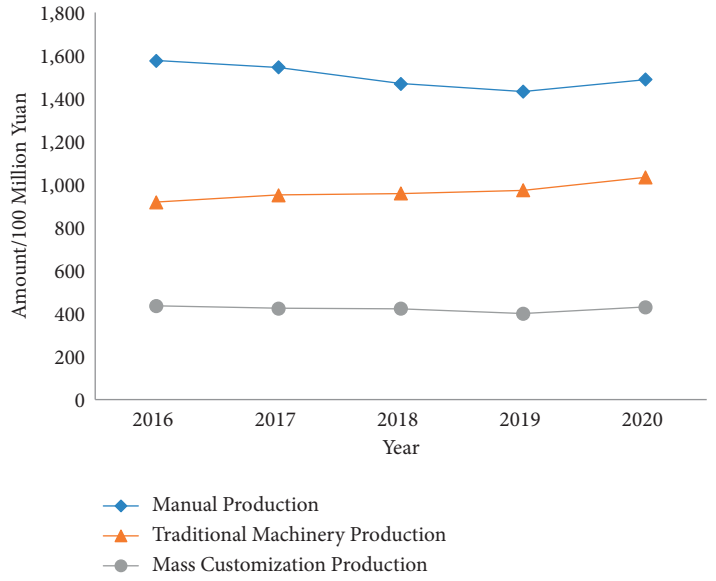

Figure 5: Production scale under different production modes.

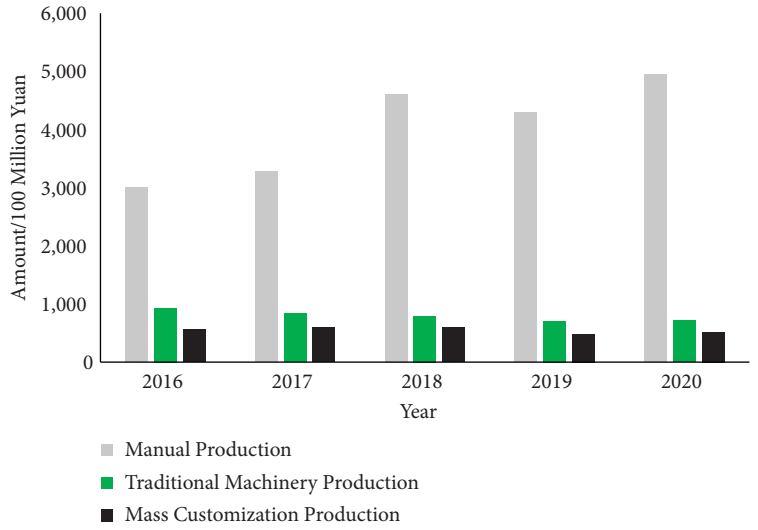

Figure 6: Consumers' consumption levels under different production modes.

participate in the transformation of the consumption mode to promote the development of productivity. From the marketing data, it is found that consumers should also actively participating in the transformation of the production mode. Figure 6 shows the consumption levels of consumers under different clothing production modes in the past five years.

Figure 6 shows that the consumption levels of consumers are improved significantly, and the clothed produced under MCM since 2016 has far exceeded the sales of that produced by traditional handmade and fixed machinery production modes. There was a slight decline from 2018 to 2019, but the sales are rising significantly from 2018 and 2019. In general, from 2018 to 2020, consumers' consumption levels of clothes show a slow growth trend. And MCM has become the mainstream clothing production mode in the market. This mode is recognized by the vast majority of enterprises and most consumers.

Compared with the data in Figures 5 and 6, the ratio of enterprise investment and clothing consumption is close to 5 : 1. In the traditional handmade production mode and the fixed machinery production mode, the gap between them is small. This shows that the profit of enterprises under MCM is far higher than that of the other two traditional production modes. The rapid development of MCM is mainly because it can bring huge profits to enterprises, and these profits will also promote the great transformation of MCM.

3.2. Digital Clothing Design. DT is used in all aspects of clothing design. First, it is applied to the design of clothing layout, as shown in Figure 7.

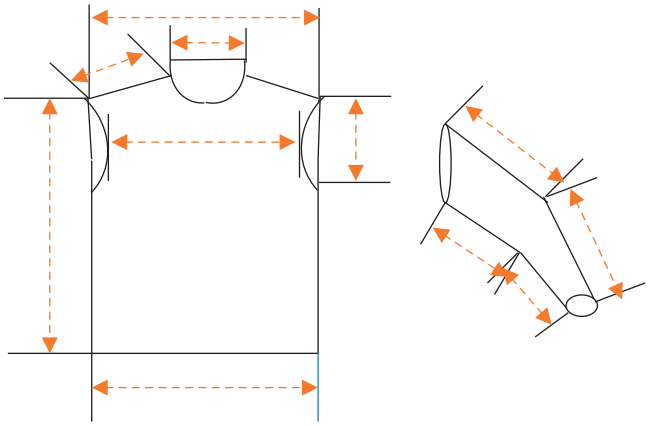

Figure 7: Design layout based on DT.

Figure 7 shows that, in clothing design, the first thing to be considered is the style of clothes, and DT can make style design more simple. First, the specific layout of clothes should be outlines with lines, which can be carried out step by step; that is, the customized service is provided more carefully after the different clothing parts are designed separately. Finally, the parts of the separate design are assembled and the overall effect is presented. In the process, the design of different parts can be adjusted according to the overall effect until the consumer's requirements are met. MCM based on DT greatly promotes the development of enterprises and economy. Figure 8 shows the effect of parts integration in clothing design based on DT.

Figure 8 shows that the overall effect of clothing design is presented after the design of each part is combined. After the simple lines of all parts are integrated, the whole combination can be colored. In coloring, it can show consumers different coloring effects to provide more opportunities for consumers to choose. After the color selection is completed, the clothing can be designed. Figure 9 shows that different drawings can be filled through virtual design to show different styles.

Figure 9 shows that clothes show different styles after different drawings are filled, and the styles can also be changed according to the needs of consumers, increasing the sense of experience of consumers in clothing design and meeting consumers' consumption needs. In addition, when clothes are designed, consumers can have an all-around fitting experience because the effect is presented through 3D simulation experience based on DT. Figure 10 shows the near-realistic experience provided to consumers on the basis of DT.

Figure 10 shows that the basic body shape can be clearly observed by the consumer after 3D scanning. According to the 3D image, the clothes designed can be adjusted in size. The body image of the consumer is processed by DT to try on the clothes so that consumers can make some adjustments according to the effect and choose their favorite style. The designer sends the production index to the production factory according to the choice of consumers. The factory uses the materials that consumers initially choose to produce

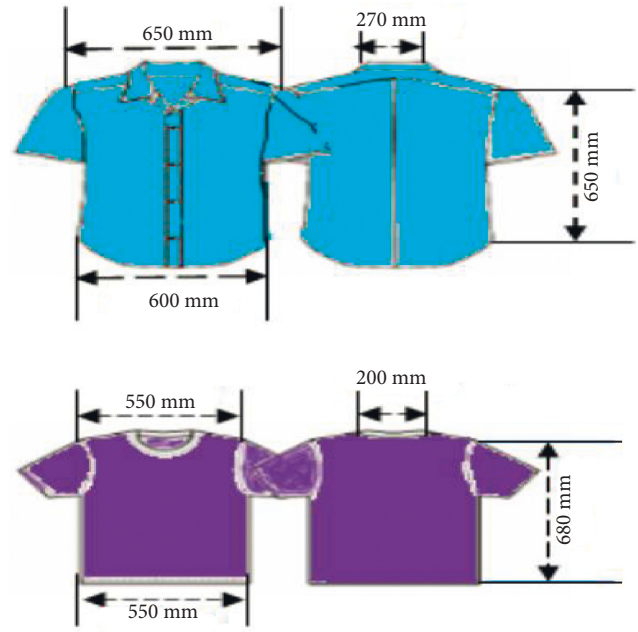

Figure 8: Effect of parts integration in clothing design based on DT.

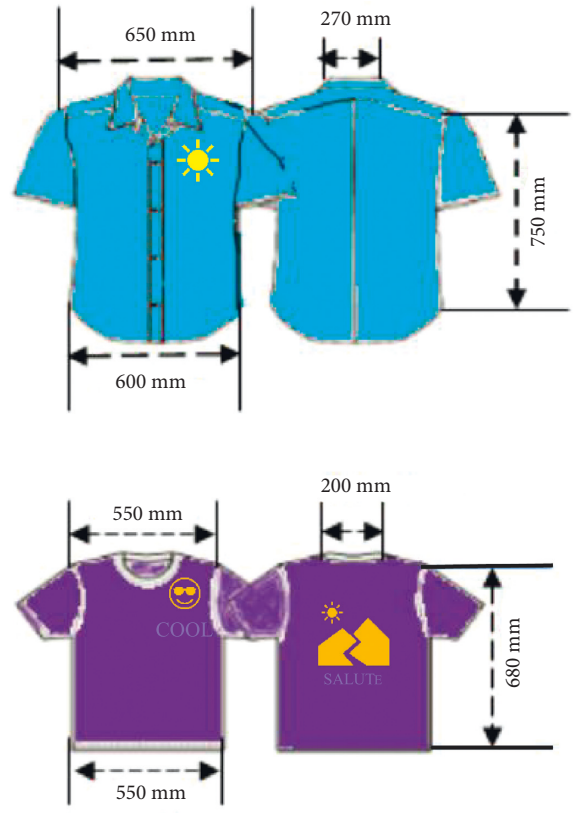

Figure 9: Different styles after different drawings are filled.

clothing, and finally deliver the produced clothes to consumers.

Clothing design based on DT is very convenient and applicable. DT can make different parts of the clothes

Figure 10: Effect of clothes presented through 3D simulation experience.

designed one by one, and the overall style of the clothes can be adjusted in time after the integration effect of different parts is presented. In terms of color, different effects can also be tried through the design software so that the most suitable color can be selected by consumers. After that, different drawings can be added according to consumers' preferences to improve the texture of the clothing. Finally, through DT, 3D images of the consumers' body wearing the clothes designed are obtained to show the effect. The whole process arouses the consumer's desire to consume and ultimately promotes the development of the entire consumer market.

4. Conclusions

The current situation of MCM is studied. The results show that the current clothing production mode and consumers' consumption concept change greatly. First, MCM based on DT is gradually popularized in the production process of enterprises. Second, consumers are also more inclined to purchase clothes produced under MCM because such products can meet consumers' consumption needs to a greater extent. Finally, the simulation results of clothing design show that the clothing designed following DT is faster, more flexible, and diversified, and DT dominates the production scale of clothing production. However, the research is not perfect, and the specific methods of clothing design are not mature enough, which will be the focus of the follow-up research, hoping to expand the application of DT in clothing design under MCM.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

References

[1] S. Nagahara and Y. Nonaka, "Product-specific process time estimation from incomplete point of production data for mass customization," *Procedia CIRP*, vol. 67, no. 000, pp. 558–562, 2018.

[2] X. Q. Xiong and Z. H. Wu, "Development and application technology the mass customization furniture," *Journal of Nanjing Forestry University (Natural Sciences Edition)*, vol. 37, no. 4, pp. 156–162, 2013.

[3] T.-M. Choi, C. Ma, B. Shen, and Q. Sun, "Optimal pricing in mass customization supply chains with risk-averse agents and retail competition," *Omega*, vol. 88, no. 10, pp. 150–161, 2019.

[4] C. Martin, M. K. Hoy, T. Murayi, and M. Alanna, "Nutrient intake and dietary quality among children and adolescents by fast food consumption status: what we eat in America," *Current Developments in Nutrition*, vol. 4, no. 2, p. 235, 2020.

[5] X.-J. Zhu, H. Lu, and M. Rätsch, "An interactive clothing design and personalized virtual display system," *Multimedia Tools and Applications*, vol. 77, no. 20, pp. 27163–27179, 2018.

[6] Z. Wang and M. Suh, "Bra underwire customization with 3-D printing," *Clothing and Textiles Research Journal*, vol. 37, no. 4, p. 08, 2019.

[7] T. Riedelsheimer, L. Dorfhuber, and R. Stark, "User centered development of a Digital Twin concept with focus on sustainability in the clothing industry," *Procedia CIRP*, vol. 90, no. 000, pp. 660–665, 2020.

[8] J.-P. Virtanen, K.-N. Antin, M. Kurkela, and H. Hyyppä, "The feasibility of using a low-cost depth camera for 3D scanning in mass customization," *Open Engineering*, vol. 9, no. 1, pp. 450–458, 2019.

[9] A. Obeidat, H. Nabawi, O. Hashem, and H. El-Said, "The impact of using interactive interior design on enhancing the

performance of clothing shop," *Journal of Design Sciences and Applied Arts*, vol. 1, no. 1, pp. 146–153, 2020.

[10] S. Mosleh, M. A. Abtew, P. Bruniaux, G. Tartare, Y. Xu, and Y. Chen, "3D digital adaptive thorax modelling of peoples with spinal disabilities: applications for performance clothing design," *Applied Sciences*, vol. 11, no. 10, p. 4545, 2021.

[11] Z. Xu, L. Xu, Y. Fan, X. Guo, and J. Li, "Study on the influence of yi handmade embroidery and fast fashion clothing combined development on the achievements of poverty reduction in liangshan area," *Open Journal of Social Sciences*, vol. 09, no. 6, pp. 407–417, 2021.

[12] K. M. Hyeok, L. W. Jin, L. D. Hee et al., "Development of nanofiber reinforced double layered cabin air filter using novel upward mass production electrospinning set up," *Journal of Nanoscience and Nanotechnology*, vol. 18, no. 3, pp. 2132–2136, 2018.

[13] A. A. Saratov, "Synchronizing the operation of workshops in custom production," *Automation and Remote Control*, vol. 82, no. 3, pp. 481–489, 2021.

[14] J. Xu, H. M. Tran, N. Gautam, and S. T. S. Bukkapatnam, "Joint production and maintenance operations in smart custom-manufacturing systems," *IISE Transactions*, vol. 51, no. 4, pp. 406–421, 2019.

[15] K. Kovacs, F. Ansari, and W. Sihn, "A modified Weibull model for service life prediction and spare parts forecast in heat treatment industry," *Procedia Manufacturing*, vol. 54, no. 9, pp. 172–177, 2021.

[16] C. Rocha and L. G. Miron, "The house factory: a simulation game for understanding mass customization in house building," *Journal of Professional Issues in Engineering Education & Practice*, vol. 144, no. 1, pp. 01–08, 2018.

[17] J. Siderska and K. S. Jadaan, "Cloud manufacturing: a service-oriented manufacturing paradigm. A review paper," *Engineering Management in Production and Services*, vol. 10, no. 1, pp. 22–31, 2018.

[18] M. Fathi and M. Ghobakhloo, "Enabling mass customization and manufacturing sustainability in industry 4.0 context: a novel heuristic algorithm for in-plant material supply optimization," *Sustainability*, vol. 12, no. 16, p. 6669, 2020.

[19] C. Liu and J. Yao, "Dynamic supply chain integration optimization in service mass customization," *Computers & Industrial Engineering*, vol. 120, no. 07, pp. 42–52, 2018.

[20] J. Zabatiero, L. Straker, A. Mantilla, S. Edwards, and S. Danby, "Young children and digital technology: Australian early childhood education and care sector adults' perspectives," *Australasian Journal of Early Childhood*, vol. 43, no. 2, pp. 14–22, 2018.

[21] J. A. Naslund and K. A. Aschbrenner, "Digital technology for health promotion: opportunities to address excess mortality in persons living with severe mental disorders," *Evidence-Based Mental Health*, vol. 22, no. 1, pp. 17–22, 2020.

[22] G. S. Aujla, N. Kumar, A. Y. Zomaya, and R. Ranjan, "Optimal decision making for big data processing at edge-cloud environment: an SDN perspective," *IEEE Transactions on Industrial Informatics*, vol. 18, no. 000, p. 1, 2018.

[23] P. Valerio, P. Antonio, P. Antonio, and G. Sperli, "Benchmarking big data architectures for social networks data processing using public cloud platforms," *Future Generation Computer Systems*, vol. 89, no. 11, pp. 98–109, 2018.