

Product design in fashion industry as a mean to ensure sustainability

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Abstract. In the fashion industry during the process of product development companies operating in this sector try to develop products in order to fulfil consumer's requirements that are in continuous changes. The whole process includes several steps followed to ensure consumers satisfaction but at the same time to sustain a sustainable production. Within the fashion industry these trends are spreading in order to meet various criteria under the umbrella of sustainability. In this context this work contributes towards using a variety of methodological and technological tools, in order to promote the sustainability design principles taking into account its three pillars. The jewelry and accessories industry were selected for building a case study that is able to offer customized products, with the customer involvement, the use of computational design and 3D printing using recycled material for prototyping.

INTRODUCTION

Product development is a term encompassing a range of activities followed by the company, that includes from the initial concept, the product design, the simulation/evaluation and arrives at the final product. The resulting products may derive from an innovative idea that is developed or improved product from a previous one. All these result from market research conducted by companies in order to meet customers' requirements that are in continuous change. Even in the fashion industry, product design is a complex process that includes a series of activities followed from the designer in order to offer the design ready for other steps of product development. Undoubtedly, the wide spread use of various technologies in product development has impacted the fashion industry. The adoption of these new technologies in various steps of product design helps expanding the sustainability principles in a variety of ways. All the three pillars of sustainability design (ecological, economic, and social) can work towards a successful product that can attract a great deal of attention [1], [2], including the other two pillars as aesthetic and cultural in their design process [3]. In the area of digitalization, we are all faced with digital technology that is having a great impact not only in the whole process of product development, but including our lives. Meantime, products are offered in a digital way prior to the final product. These trends are becoming a normal way of living and where consumers are more and more included in this process by interacting with product design process, which is offered by various companies operating in these sectors. Advanced technologies, such as 3D modeling, 3D scanning,

simulation, 3D printing, etc., available on the market and used from various industries have changed the way of product design by developing products in a short time, with lower cost and at the same time raising quality. The last one is of a high importance for example in the case of garment used for technical purpose where 3D anthropometric data help to improve fit [4].

Ensuring sustainability as an emerging need required from fashion industry

The most known definition of sustainability is “sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs” according to UN Word Commission on Environment. In other words, sustainability is a term that includes the way of creating and using various resources in order to reduce pollution, reduce waste and sources available not only for our generation but the future generations too. Ensuring sustainability is an obligation required everywhere. Starting from the first process of designing, that play an important role for product development, it is evaluated that 80% of environmental impact is defined at the design stage [5]. The role of a designer is crucial during the transition from a linear to a circular economy [6]. According to European Commission, products as apparel and fabrics are names as products for the circular economy [7]. Bearing this in mind, for the designers is another challenge to create products that are easily to be recycled or used for a long time [8]. Ensuring sustainability in the textile industry should be promoted by all actors operating in this sector [9] and interdisciplinary approach is needed in order to break barriers and find opportunities to develop fashion and textiles within circular economy [10]. Fashion products are made from various types of materials and their selection is dictated by the type of product that should be produced. Considering the fact about sustainable production due to the increasing awareness of environmental pollution, since at the early stages of product development as product design plays a key role to ensure sustainability. Product designers use CAD software to create virtual replicas of the upcoming physical product. Moreover, these prototypes can be easily simulated as a mean to make first evaluation of them. The whole process of product design is an interactive process to test different ideas that at the end should fulfill not only consumer’s requirements but offer a product that is sustainable. In the life cycle evaluation of clothing products extending garments use, by designing, maintenance and re-use contributes to reduce negative impacts of clothing products [11].

Additive manufacturing is one of the technologies that play a crucial role by supporting a sustainable production. Its principle is based on producing the 3D model under consideration in a layer-by-layerway, directly from the CAD data, thus resulting in using less material compared to the traditional manufacturing method. 3D printing is a very fast-growing era and is further developing from a variety of directions. The use of plastic material mainly used in the fashion industry for footwear and accessories, has a lot of sustainability related issues involved. Recycling these materials and producing filaments used for 3D printing, which can be completely recycled or a mixture of a percentage recycled and raw material can help towards this direction. The filaments that someone can reach easily in the market are made from a variety of thermoplastic raw materials. Meanwhile, some filament manufacturers have started offering recycled based material for use and some users purchase equipment for filament self-production [12].

The use of HDPE (High Density Polyethylene) in both the injection molding manufacturing processes and the 3D printing applications offer a lot of advantages for recycling and adoption of the circular economy principles [13]. In addition, a lot of opportunities are offered for improvements in biodegradable filaments in 3D printing. The gradual loss of the filament properties puzzle both researchers and manufacturers that are trying to overcome this obstacle and offer long lasting thermoplastic materials to serve the 3D printing manufacturing industry [14].

Modern CAD/CAM technologies support the design cycle from start to the end and the designer can take advantage of high-end pieces of software together with under development technologies in 3D printing. All these can be combined with sustainability principles and methodologies via the designer. The designer is able to work as engineer and artist at the same time by urging the best choices to be made very early during the product design cycle [15]. Manavis and Kyratsis used computational design together with a series of methodological tools with an aim to design impressive and unusual products for supporting a brand identity. These products are not only built based on a brand idea but are supported by modern manufacturing technologies i.e., 3D printing, laser cutting and engraving [16]. The aim of the present paper is to increase the user awareness about how the product design life cycle can be influenced by recycled materials for their prototypes and manufacturing purposes. The whole process is described from the conceptual stage until its prototypes both virtual and physical. The proposed methodology can be applied

for a variety of products within the fashion industry and for this case the accessories and jewelry era were selected. Extensive use of visual and actual prototypes together with 3D printing is used by including recycled material.

Methodology

The proposed methodology combines both methodological and technological tools. Figure 1 depicts the roadmap followed during the development of the case study. A number of creativity tools were used in order to explore new ideas and visualise the different concepts. The mind map was used for producing an increased number of possible directions, very early in the design cycle, the mood board and a variety of sketches were the basis for the initial digital representation of the ideas to be implemented. Based on the initial sketches, CAD models were produced and design alternatives were presented. Those CAD models use visual programming technology with an aim to produce families of products quickly and effectively. Finally, digital rendering and 3D printing were applied as a mean to evaluate the proposal.

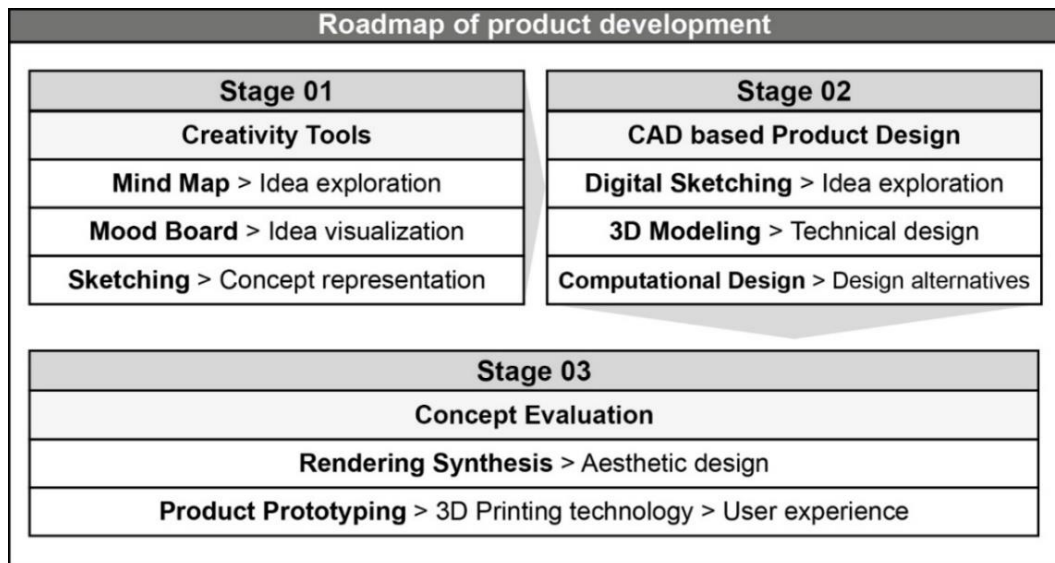


FIGURE 1. Roadmap of product development.

Case study developed

Traditionally the role of designer in the fashion industry is crucial from the inspiration point of view. Nowadays, there is an effort to use modern tools such as computational design in order to create unusual geometries and forms that can attract the possible customers (figure 2). Although the main problem of these complex geometries has been the manufacturing processes to be implemented, in the last years, 3D printing has become a mainstream procedure in manufacturing by offering the desired solution in prototyping[17]. As one of the advantages of 3D printing technologies producing complex geometries is not anymore, a challenge due to the possibilities offered by this technology. There are different materials used for 3D printing and the most common are PLA (Polylactic acid), ABS (Acrylonitrile butadiene styrene), TPU (Thermoplastic polyurethane). However, a great deal of research is under development for new materials [18]. But the idea of using recycled material for all the 3D printing related activities can offer additional advantages. Of course, this can be a very challenging task, because the quality of the recycled material is worse than that of the newly produced one. On the other hand, this strategy can be used as an advantage from the marketing department with an aim to capitalise the use of recycled material towards the future customers, gain great attention and increased sales.

A very important area of fashion design that attracts a great deal of attention and deals with increased added value produced is the jewellery industry. In this case, the added value perceived by the customer offers large potentials for exploration and new design, prototyping and manufacturing techniques. Figure 3 depicts the steps followed in order to establish a new idea for customised jewellery design. Further use of methodological tools i.e.,

mind map, mood board, sketches, in close relation with preparing the appropriate code within Grasshopper™ result a family of customised jewels.

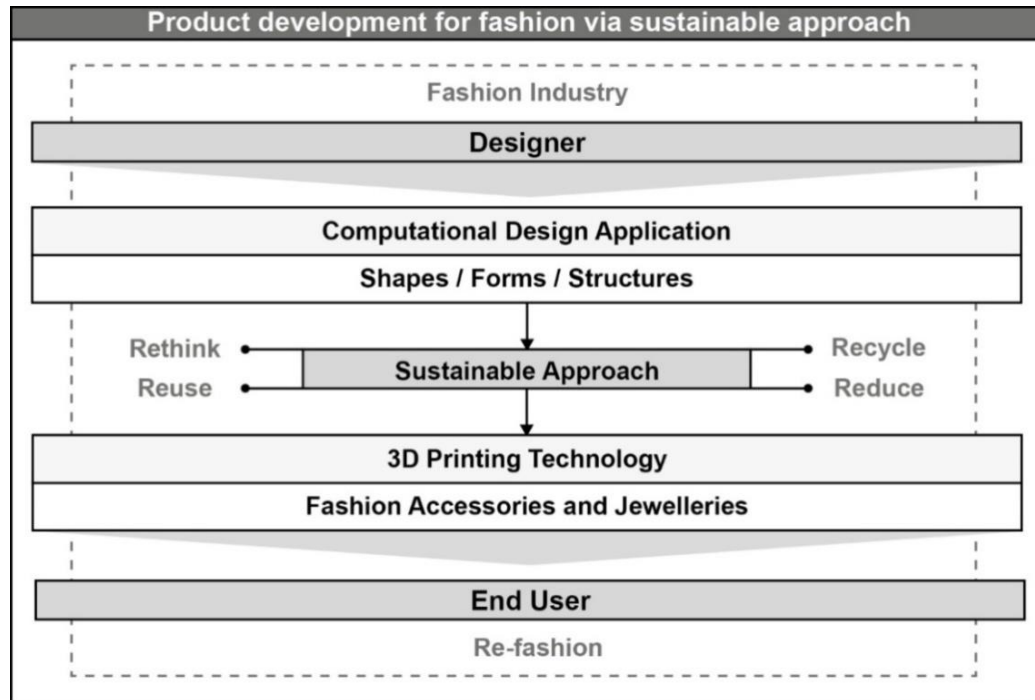


FIGURE 2.Product development workflow based on sustainability.

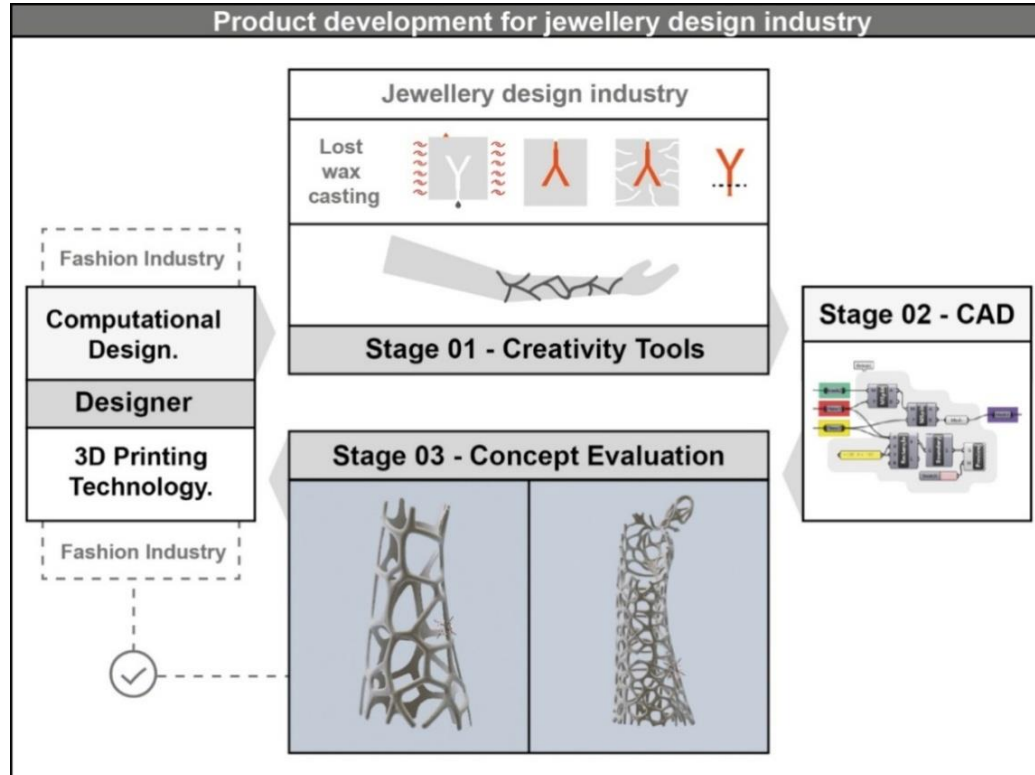


FIGURE 3.Product development using computational design tools.

The arm of the user is 3D scanned and from the data generated, a 3D .stl file is created. This file, which is unique for every customer is used as an input at the Grasshopper™ based application. The geometry that will be modelled is limited between two planes perpendicular to the arm. A variety of lengths and positions can be used in order to make it suitable and appropriate to the customer involved (figure 4). Then more parameters dealing with how much density is required are set. Their implications to the cost due to the increased material required can lead to the final set of parameters and finalises the end customised product. It is obvious that such unique design can attract customers of high income and thus it can offer increased profits.

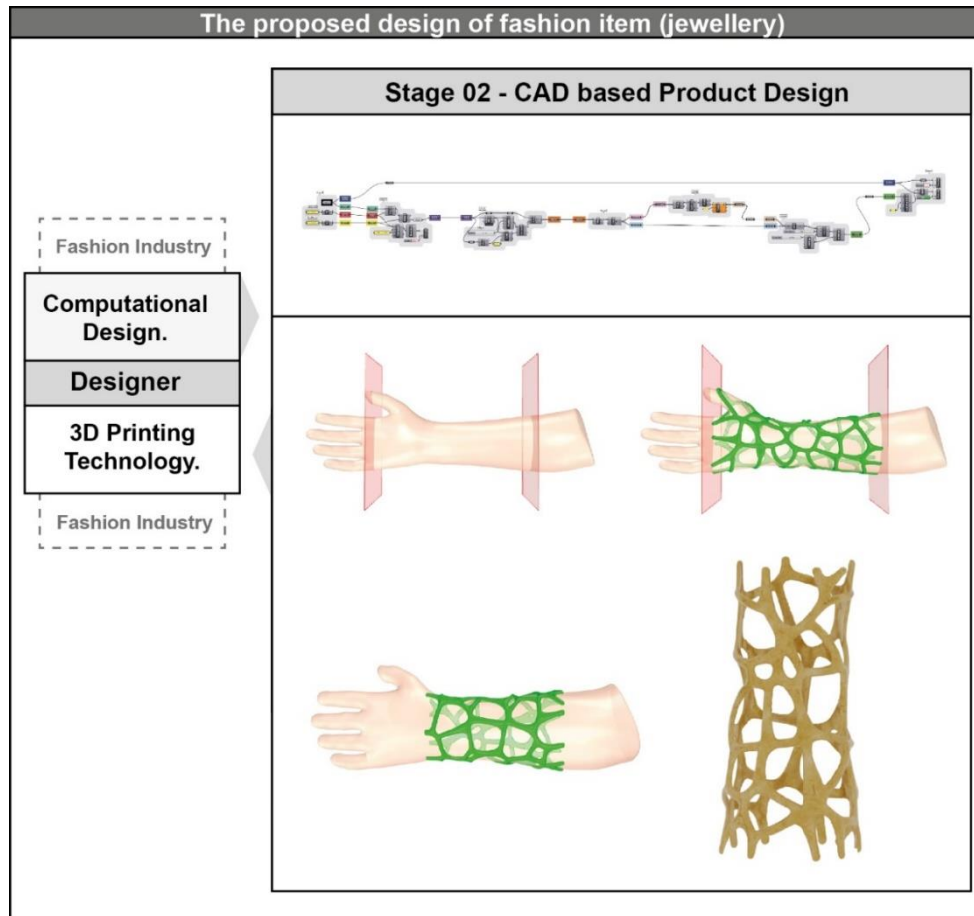


FIGURE 4. *The proposed design of fashion item – jewellery.*

At this stage, the question of producing the jewel prototype can be answered very easily because such complex geometry can be made basically only by using 3D printing. In this case, the efforts were to use recycled material for 3D printing the prototypes, while the same technique of 3D printing can be used, for creating later during the final production stage, as the basis for building the manufacturing moulds. Instead of purchasing pure material the idea of using recycled materials as a mean for a sustainable production seems to be a good example for other applications too. As a result, the main idea towards creating a quantity of material that was coming from recycled HDPE (High Density Polyethylene) and PLA was developed. A large amount of bottle caps deriving from used water bottles was selected. After that the caps were cleaned and then by using a SHR3D-IT shredder, made by the 3Devo manufacturer, an increased portion of HDPE was converted into 3D printing material (flakes). An AIRID polymer dryer (approx. 50°C inside the chamber) by the same manufacturer was used for removing moisture from the produced material and thus improving its properties for the step to follow. A mixture with 50% of recycled HDPE and 50% PLA was then used with a COMPOSER Series 450 filament maker from 3Devo in order to extrude

filament with 1.75mm diameter using temperature of 220-230°C. Figure 5 depicts some steps followed during material and product development.

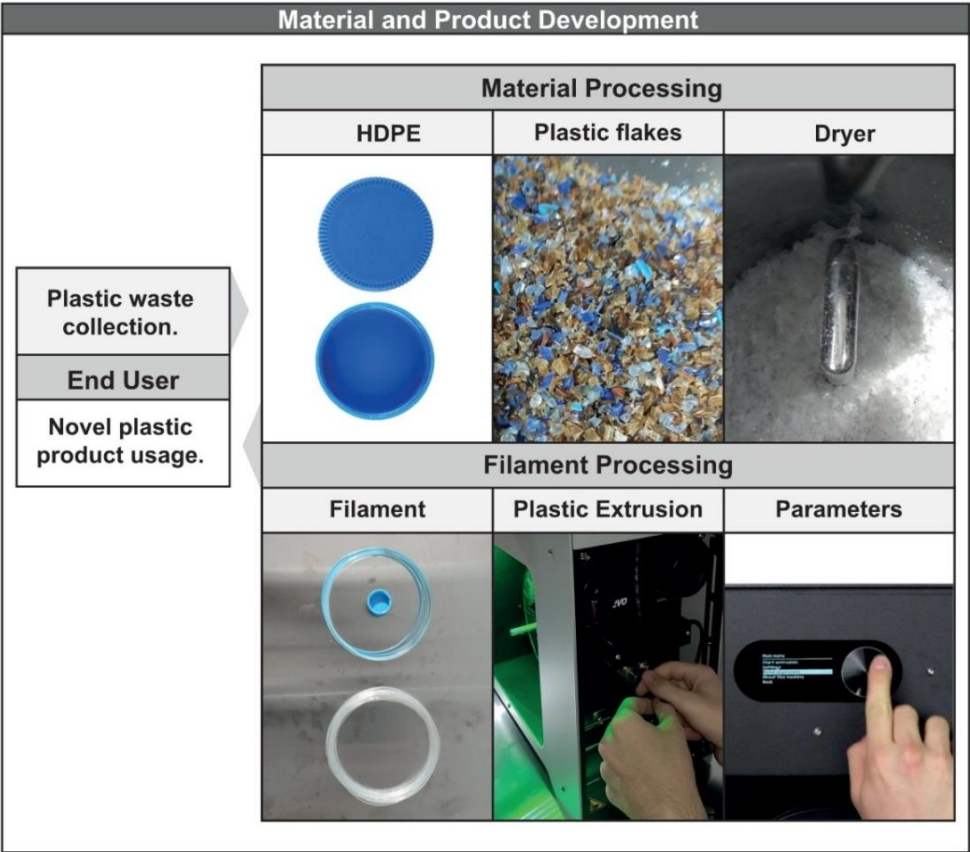


FIGURE 5.*Filament developed via recycled HDPE and PLA.*

The material produced was used with a Creatbot D600Pro 3D printer with an aim to produce the prototype of the 3D CAD model implemented earlier. The 3D model was layered and then printed in details. The final product was received and further processed in order to remove the supports and clean it from some dimensional inaccuracies encountered (Figure 6). The customer could then test the prototype of its customised design and sense the increased experience of acquiring a unique piece of jewel (Figure 7)

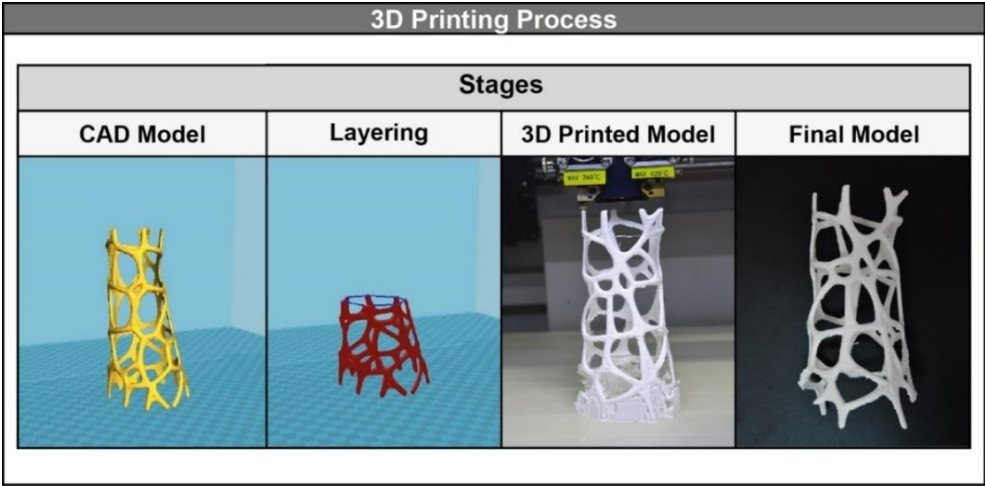


FIGURE 6.3D printing process and prototyping.

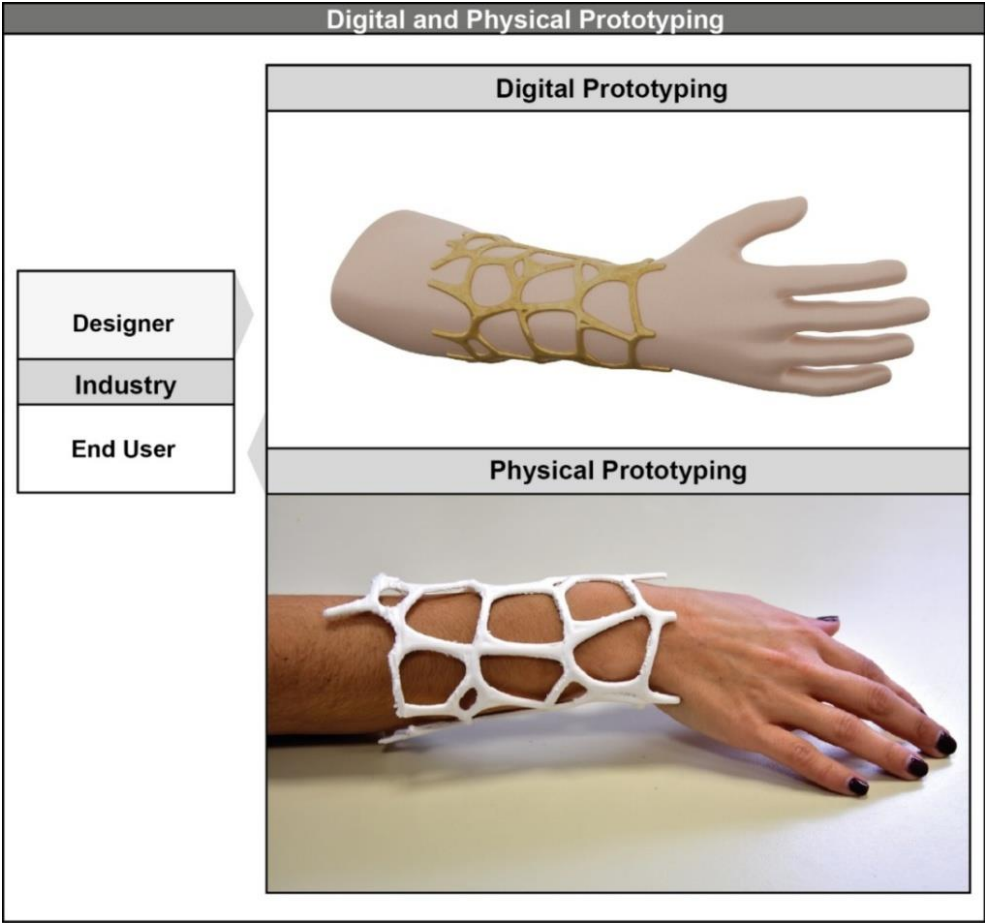


FIGURE 7.Digital and physical prototyping - user experience.

CONCLUSION

The fashion industry offers a great number of opportunities for trying new directions from both the design itself and sustainability point of view. The increased added value when designing and offering jewels is an excellent

opportunity for customised experimentations. This approach can encompass sustainability principles to a great extent.

Due to the nature of fashion products that are in continuous change linked with customers' requirements, the role of various tools offered by various software used for product design, as 3D modelling, computational modelling, rendering, 3D scanning, and prototyping using additive manufacturing offers great possibilities as a mean for a sustainable production. The last one is one of the most required in the fashion industry and others too. The case study presented was based on a variety of innovative approaches i.e., use of computational and methodological tools, produced customised jewels and prototyping with recycled material filament. Following this approach, the customer demands are met and the user is actively involved in a variety of steps from the design to the prototyping. From the sustainability point of view, all the pillars are involved to some extent. The economic aspect is met because by using different tools and technologies, the development time can be drastically reduced and thus the cost is reduced as well. The ecological aspect is achieved because of the recycled material used and finally the social aspect is covered by the intense participation of the user that receives a customised jewel.

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