Vanishing Ice

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As a type of transformable clothing, modular designs "feature small components that can be worn independently, detached, or replaced with other components, thereby creating an infinite number of combinations (Koo et al., 2014)." Many apparel designers have practiced modular designs. For example, designer Carolin Vogler created a modular top using felt fabric and laser cut (Vogler, 2018). The models can be tessellated into patterns to create different designs. Modular design has the potential for a wide spectrum of applications through its ability to transform and create personalized designs for consumers. In 2015, Dutch designer Martijn van Strien launched his label, The Post-Couture Collective, in Rotterdam. The label allowed consumers to download modular pieces and self-assemble clothing designs without the need for sewing machines (Tucker, 2015). Previous studies by the designer have also explored the use of modular pieces to create ready-to-wear modular garments for women (Chen, 2019).

While designers can use the modular concept to create original garments, one concern of modular design through past practice is the durability of modular pieces following use. As most modular garments were made out of fabric, the interlocking system of the modules could be worn out easily after frequently connecting/disconnecting. Additionally, connections on some of the fabric modules were not strong enough to hold together for high stress areas of a garment such as on the shoulders and armholes especially if the overall weight of the garment is large, due to the design or the material used for the garment. Thus, the designer searched for solutions beyond using textiles for modules and adopted a 3D printing technique to increase the durability of the modules. In recent years, 3D printing technology rapidly gained notoriety by apparel designers due to its ability to create complex shapes while reducing some of the subtractive manufacturing constraints and the enormous material wastes (Sun & Lu, 2015). Additionally, in order to test the solutions effectively, a deadstock denim fabric was chosen for this design research. Denim is one of the most widely used textiles in the fashion industry and it is considered to be heavy weight. Therefore, the purposes for this design research were 1) to create a modular garment that could be transferred into different looks using denim fabric, and 2) to explore methods of enhancing module design durability. In this research, a module's durability refers to the interlocking ability of a modular piece to remain functional during the garment life without damage or decay.

There are three components to form this design: a strapless denim dress, denim fabric modules, and 3D printed modules. The inspiration for this design originated from an image of arctic ice broken off from a nearby glacier and melting in the heating ocean. Using a hand bleach approach on the deadstock denim fabric and the modular design concept, the designer aimed to highlight both the sublime beauty and the shifting condition of the planet. The methodology of using 3D prints as modules that connected with denim fabric through 3D printed buttons was a new way of incorporating technology into modular designs.

The process started by creating the first component, the strapless dress. One yard of deadstock denim fabric was kept in a bundle with rubber bands before placing it in the bucket of bleach and water mixture. The idea was to create an abstract and uneven colored surface to represent the image of ice

melting in the ocean. Once the desired color results were achieved, the denim fabric was taken out of the mixture and rinsed thoroughly. The dried fabric was then cut into the several triangular shapes to mimic the shapes of large ice formations and icebergs. They were patched together into a flat textile from light colors on the bust gradually transitioned to dark colors on the hem. An invisible zipper was used on the center back of the dress for closure.

Next, one yard of unbleached denim fabric was laser cut into fabric modules. To prepare for the laser cutting file, the same triangle shape used on the dress was drafted on Adobe Illustrator. Slots on each of the side of the triangle were carefully positioned for interlocking purposes based on previous studies (Figure 1). After the triangular shape was used to cutout the denim fabric modules, one row of the fabric modules was sewn at the hem of the strapless dress created in the previous step to allow for the dress transformation. In this case, the fabric modules were able to be attached to the dress to lengthen the skirt on the hem by the wearers if desired without the need of a sewing machine.

Lastly, to make the 3D printed module, a set of 3D printed models titled Escher system (Hunter626102, 2019) was adopted to create the shoulder parts. Two of the models, a triangle and isosceles trapezoid, were imported and printed on an Afinia H400 3D printer with white PLA filament (Figure 2). All of the 3-D printed triangular and isosceles trapezoid modules were designed with slots on each side to be clasped together as to not come apart when force is applied. The white 3D printed modules were then clicked together to create two panels of the shoulder straps to be added to the denim dress. Since the trapezoidal module has a 3D button designed on one side, the designer utilized the function of the buttons to join the 3D printed modules to the denim dress through button holes added on the dress neckline. To provide additional transformation options, the cutout on the fabric modules can also function as button holes to join the 3D printed modules, such as adding flared sleeves.

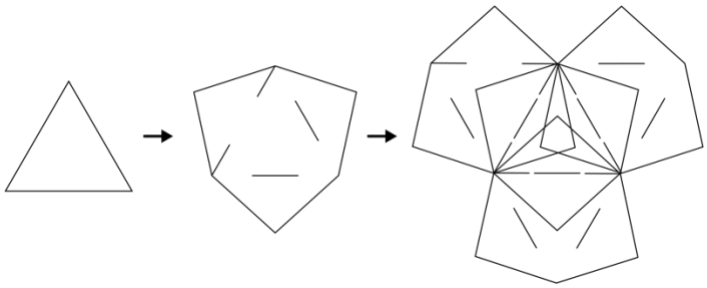

Figure 1: The fabric module and its interlocking method.

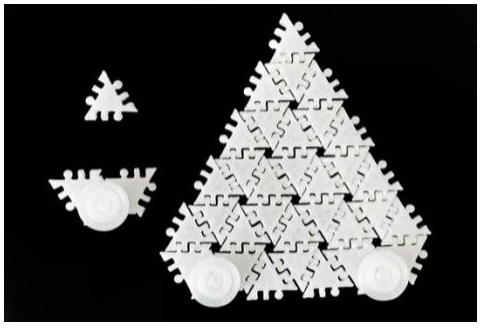

Figure 2: The 3D printed modules.

The modular concept allows the wearer to create endless possibilities. The dress can be worn as a simple strapless dress or transformed to be different looks by attaching the fabric modules and/or the 3D printed modules provided, such as to lengthen the dress on the hem or adding flared sleeves. With a strapless dress as the base of the design, this transformable garment could be easily accepted by a wide range of consumers at all skill levels. In addition, the integration of 3D printing technology into modular design allows for easy configuration and editing of designs while increasing the module design's durability, as the 3D printed modules' interlocking ability can stay functional over numerus actions of connecting/disconnecting. The 3D printed modular units are also stronger than common fabric units to

hold the weight of a heavy garment, in this case a denim dress. Finally, the methods of hand bleaching and patchwork on denim fabric resulted in a unique surface design reminding people of vanishing ice brought about by the omnipresent threat posed by climate change. This design adds value to the existing body of work regarding transformability and durability in modular design through the use of 3D printing technology.

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