

## 3D Printing for a Modern Bag

Lushan Sun, Auburn University, USA  
Sandra Starkey, University of NE-Lincoln, USA

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A busy lifestyle is commonplace in contemporary American society, and increasingly consumers are interested in products and services that are time-saving (Bellezza, Paharia & Keinan 2017). Bellezza, Paharia & Keinan contend that “busyness” has become a status symbol and this supports a need for products that can easily transition from work to leisure and or products that include multi-functional characteristics. Today, consumers are also demanding customized products that are user-friendly. In the fashion industry, direct digital fabrication technologies have frequently been used to enable efficiency in customized product design, such as digital textile printing (Continuum, 2017). Recently, a substantial interest in 3D printing (3DP) for fashion goods has increased exponentially (Durrant, 2014; Molitch-Hou Peleg, 2017). In accessory design, Nike was one of the first to market its 3D printed duffel bag with an intertwining mesh structure (Durrant, 2014). Other explorations are limited to more rigid structures with limited storage space.

Currently, 3DP technology is often utilized when creating interconnected units with free moving parts, all in a single process for wearables that require increased flexibility and comfort (Peleg, 2017). However, more designers rely on using the more expensive fabrication method, the powder based Selective Laser Sintering (SLS), to achieve articulating parts. Research and exploration are limited in the use of a more accessible 3DP method, filament based Fused Deposition Modeling (FDM), in developing flexible structures. Today, the FDM filaments are more common in polylactic acid (PLA) and limited in polyurethane (TPU), a much more flexible and durable material.

The purpose of this design study is to explore the integration of 3DP technology in a stylish yet multipurpose bag for the modern consumer. The goal is also to develop the flexible and functional structures in 3D CAD modeling process for Fused Deposition Modeling (FDM) method using thermoplastic polyurethane (TPU). Research through design (RTD) methodology was applied in this case study, and data were collected through reflexive journal documentation and video recording of the virtual design process.

Careful consideration of aesthetic properties in addition to functionality was a priority when developing this multipurpose bag. It is designed with a triangular top and base (lamb hide underlined with silk organza) with rectangular sides (waterproof synthetic blend) that form the storage space for the user. The bag is intended to allow various ways of use with the top handle (TPU in FDM) or shoulder strap. An exposed zipper was used to create the opening for the bag in the same orientation as the short strap, and a nylon lining was used to finish the bag interior. The 3D printed portion (TPU in FDM) is mainly integrated at the base and provides stability and protection for the bag to sit vertically. Inspired by a vintage bag design feature, the structure of the 3D printed part was also developed to allow flexibility and comfort for a light weight bag. The vintage clutch purse referenced was a part of the “Plasticflex”

line of handbags from the early 1940's. They were constructed of a series of individual 3-D plastic pieces that are interconnected with leather cording to create the body of the purse (U.S. Patent No. 2,256,645) (Kuhlman, 1941). The 3DP structure builds on the initial design idea of the 1940's motif and modernizes the concept by modifying the shape as well as eliminating the need for a leather cord to connect the pieces. The 3D printed pattern was printed in black and creates a strong color contrast against the off-white and gray colors in the design. This design provides multiple ways of use and styling and includes unique design details and an original silhouette. It is modern and chic and specifically for the consumer that wants innovative options incorporating new technology.

The 3D printed structure was virtually modeled in Rhinoceros (Rhino) using direct modeling techniques. Trapezoid 3D shapes were created with beveled edges and holes that references the "Plasticflex" bag pattern. Individual segments were repeated and connected with horizontal and vertical pipes running through the open spaces. The intention is that the support material from FDM printing will help to hold in the long pipes in place inside the holes of the trapezoid pieces. The structure was sampled with both nylon and TPU to evaluate the quality and flexibility needed for the design. The finalized structure was customized for the triangular base of the bag. A wall, a lip, was designed to allow the bag to sit inside of the base structure comfortably. Patternmaking and bag construction techniques were applied in the final prototype assembly.

This case study also suggested some challenges exist in developing such a multipurpose bag integrating 3D printing. One of the primary concerns is the durability and flexibility of the material and structure. Also, the designer has limited capability to fully evaluate the final 3D printed structure during the 3D modeling process. The resulting design showcases a unique 3D printed pattern grouping that flexes without the intricate or complex structure that requires a high level of 3D modeling skills. The key innovation in this part also lies in the use of FDM support structure/materials as a part of the design that manipulates the final structural behavior.

The findings of this design research contribute to new approaches to the field of 3DP integrated in fashion products. It explored the potential and benefit of using 3D printed parts as functional and stylish components for a trendy bag. The 3D modeling process was found to be efficient with the use of support material in FDM printing. As a low-cost fabrication method, the FDM 3DP should be further investigated in developing comfortable and customized fashion product categories. Additionally, future prototypes for the 3D printed bag could include convertible and customizable features to reflect changing lifestyles to better suit the needs of the modern consumer.

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