Flex, Breathe, Fit, and Walk: Exploring Technologies Accessible in Academia for Design and Production of a Custom Fit Shoes

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This exploratory design research was conducted to investigate the existing technologies accessible in academia to design and produce a sample pair of shoes with respect to standards implemented in footwear manufacturing. In this design, three factors were explored: flexibility in material and forms, breathability, and custom fitting. In this design, customized shoe sole and footbed was designed and 3D printed based on the participant's foot shape. Researchers suggest the cushioned or shock-absorbing shoe insoles not just protects against injuries but reduces the impact forces result from running (Braun & Baritz, 2017). Therefore, in this design, the 3D printing materials for the shoe sole and footbed as well as fabrics for the upper part of the shoe were selected from flexible materials and gels. The material used for 3D printing the shoe sole and shoe bed is a liquid base form called Tango which has a rubber-like quality to create a realistic prototype. This material is for use only with PolyJet™ 3D Printer. According to Sun and Zhao (2017), "the properties of various 3DP materials can be manipulated through 3D modeling techniques that allows more flexibility and comfort in the final printed products" (p. 5). Therefore, in order to implement additional flexibility in shoe sole, the pattern of the sole followed the living hinge texture technique to guaranty the movement and bendability without breaking the material. In order to assure the shoe is breathable, the living hinge in the shoe sole and tiny holes applied in footbed works as a vent to release the excess heat to the outside area. Similarly, the spacer mesh material for the upper part transports moisture vapor and heat away and allows air flow.

In the footwear industry, the patterns of the upper part of a pair of shoes is made by drawing directly on top of a wooden form called a last. In this design, the last was customized to represent the participant's particular foot shape. In order to prepare the customized last, the foot was 3D scanned using Structure Scanner on iPad. For this purpose, the foot was placed flat in the middle of angled plexiglass to capture every corner of the foot shape. Afterward, the 3D data was processed and cleaned in Autodesk® Fusion 360™ which is a free 3D CAD/CAM design software for students and educators. The size of the foot was double checked before moving to the next step. In this stage, the virtual model of the foot was sliced with Slicer for Autodesk® Fusion 360™. The thickness of sliced layers depends on the thickness of the material chosen for making the foot form. After obtaining the patterns of each slice, they were modified and cleaned in Adobe Illustrator. The final file was prepared and saved in Corel Draw in order to cut each slice with a laser cutter. Foam board of 1/8” thickness was laser cut to obtain foot form slices. Afterward, the foot form was assembled by inserting two dowels in each layer and gluing them together (Image 1).

Based on the customized foot form, the model of the upper part of the shoe was created. On this stage, the foot form was covered with large paper adhesive tapes. After obtaining the desired shape, the adhesives were carefully detached from the form and places flat on cardboard to transfer the pattern on it. Because the participant was a female, the design followed curved lines like flower petals on the *ankle collar* and *quarter panel*. Templates for the various parts of the shoes upper were then cut out of the cardboard (Image 2). The pattern was digitized to obtain the digital form of them. The materials of the shoes upper were selected from *spacer mesh* in gray and white colors to guarantee the breathability and flexibility as well as the comfort. Fabrics were laser cut following the patterns of the upper shoe. Laser cutting guarantees clean edges and additional accuracy for small pattern pieces. The side panels/quarter panels were laser cut from two layers (plastic sheets and heavy rubber coated polyester fabric) fused together. These materials hold shoelaces securely as well as support the ankle part and sides of the foot. Various parts of the upper shoes were stitched together by machine and hand stitch methods.


Image 1

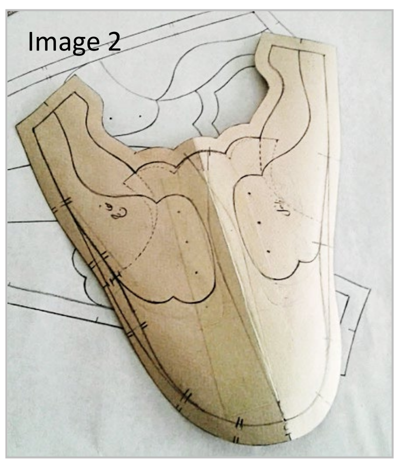
Image 2


Image 3

The shoe sole and footbed both were created by Fusion 360™ starting with the virtual foot form. Supposing the shoe sole must represent the exact form of the foot sole, looking at the foot form from the bottom view, a line with 1/8” distance from the actual perimeter of the foot sole was drawn. This line traced the same perimeter of the foot sole with a 1/8" distance. This perimeter shaped the basis of the shoe sole. The footbed, as well, was designed following the same perimeter. After finishing the design of both shoe sole and footbed, the scale of the shoe sole was slightly enlarged to ensure the sufficient space for the fabrics of the upper part (Image 3). Both shoe sole and footbed were 3D printed with PolyJet™ 3D Printer using a rubber-like material called Tango. The shoe sole was 3D printed from opaque gray, and the footbed from a transparent gel. After the shoe sole was ready, the upper part was assembled to the sole using Gorilla Epoxy glue and applying pressure for few hours. This shoe has been tested with the participant to ensure the initial goal of this experimental design was met.

To summary, creating shoes using 3D printing technology, 3D modelling and traditional manual techniques requires both technology and handmade knowledge. This will result in using both 3D visualization and tacit knowledge. In addition, current technologies such as 3D CAD software (which some of them are free to use for students and educators) and 3D printers could assist to create realistic footwear prototypes and samples to use for various research and design purposes.

References:

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