Design Cognition in 3D Modeling Wearable Product: Exploring Challenges and Transitions for Apparel Designers

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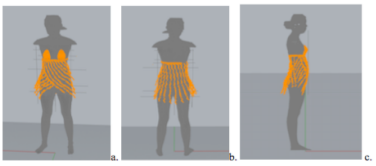
With recent expansion and advancement of 3D printing (3DP) technology, the textile and apparel industry is taking notice of its vast potential in developing an efficient and sustainable manufacturing process for customized products. As part of this digital fabrication process, computer-aided 3D modeling becomes critical for apparel designers in integrating 3DP technology and creating complex objects. Currently, most apparel designers have been trained to rely on hands-on studio practice. Many case studies have suggested that hand craft practitioners who have more haptic-based training, or manual exploration skill, are more likely to experience challenges in CAD-based digital crafting, especially using rather static computer tools. The challenge lies in understanding the human-computer interaction (HCI) and the cognitive process for an apparel designer in 3D CAD product development. Further, scholars have pointed out that the cognitive activity often involves the use of spatial and object visualization skills (Kozhevnikov & Hegarty, 2001) as well as visual (Cattaneo et al., 2006) and haptic memory (Gallace & Spence, 2014). All these activities play an important role in understanding the visuo-spatial structure and process in 3D CAD reasoning and problem-solving. This case study explores ways the traditional apparel designer transfers tacit knowledge gained in the physical world to the virtual environment in 3D modeling of a wearable product. The research question was: how do the apparel designer's visual and haptic experiences from the HCI affect the visuo-spatial cognitive process of 3D modeling using a human avatar as the virtual dress form?

This design research followed the naturalistic inquiry approach and adopted the research through design methodology (Jonas, 2007) in conducting a firsthand exploration of 3D CAD. Data collection followed the reflective practice concepts, or reflect-in-, -on-, and –for-action, and a reflexive journal was used to purposefully document reflective thinking, memo, idea, mind mapping, and/or sketching during virtual design. Content was hand recorded approximately every 20 minutes of the 3D modeling process and was later theme coded for analysis. At the same time, computer screen recording was used to capture all 3D CAD processes and coded using professional video analysis software. The professional 3D CAD software, Rhinoceros, was utilized, and a misses size 8 body scan was converted into a human avatar to serve as the virtual dress form. The wearable product was conceptualized as an empire waist dress composed of unique spiral ribbon structures diagonally positioned around the body (Figure 1.a-c.). In analysis, qualitative data was sorted by the different sections of the garment, including bodice cup, bodice band, skirt front, skirt back, and skirt side. The computer screen recording was coded in seven categories, including the various 3D



CAD actions (i.e. zoom in/out), object movement (i.e. manual object rotation), object format (i.e. curve), object transformation (i.e. split object), design efficiency or organization (i.e. duplicating object), and miscellaneous activities (i.e. tool search). The coded screen recording results for each garment section were then analyzed against the reflexive journal content that was coded in six categories, including tacit knowledge application, visualization, object manual exploration, solutions, organization/ planning, and miscellaneous considerations.

In general, the 3D modeling process was mainly a visual oriented experience, and spatial knowledge was critical in modeling all parts of the garment due to the constant evaluation of space and/or distance between garment and avatar. Also, the tacit knowledge brought into the digital design process from traditional apparel design was applied in the garment parts where close fit and contouring were needed, such as the bodice cup and skirt front. Where the body had more curve changes, more haptic memory from previous design practice was also referenced due to the complexity of the 3D CAD procedures in accomplishing the fitting task. Further, spatial visualization skill was frequently applied to mentally rotate garment components in different perspectives to foresee the outcome and plan the subsequent CAD procedures. On the other hand, visual memory from tacit knowledge was retrieved in form of mental imagery and often applied with the use of object visualization skill to see only the appearance of an object. Lastly, previous experience and knowledge of the intended 3DP machine (SLS) and material (nylon) use was also referenced in evaluating material properties and capabilities in the overall garment design, 3D modeling and planning. It was found crucial in the way a traditional apparel designer transitions into the 3D digital design environment.

This case study was limited in the designer's tacit knowledge, garment structure created, 3D CAD program utilized, computer-based device (3D mouse) applied, as well as the 3DP technology considered in product development. In the future, apparel designers need to develop a more efficient workflow for evaluating fit in 3D modeling wearable products and allow time to develop tacit knowledge in both additive manufacturing and 3D CAD. More importantly, designers with traditional hand crafting backgrounds need to recognize the differences between the two modes of design/making and the additional knowledge and skills that the traditional apparel designer needs in advancing professional design practice, research and education.

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