

## The 3D Printing Era: A Conceptual Model for the Textile and Apparel Industry

Lushan Sun, University of Missouri, USA  
Sheng Lu, University of Rhode Island, USA

Key words: 3D printing, conceptual model, Textile and Apparel industry

The rapidly emerging 3D printing (3DP) era has triggered attention in a diverse range of sectors and its applications. This transformative technology is most attractive in its ability to essentially reduce some of the subtractive manufacturing constraints, such as costly machinery, workflow procedures, labor inputs as well as the enormous material wastes. Considering the rapid advancement and development of 3DP technology, experts have envisioned that the Textile and Apparel (T&A) as one of the major industries where 3DP the technology would have a wide application and more disruptive impacts (Lipson & Kurman, 2013) on the way that T&A industry currently operates. Based on examining existing literatures, this paper proposes a conceptual model that summarizes the potential impacts of 3DP technology on the big landscape of the T&A industry. The intention is also to provide a valuable framework for the T&A academic discipline to proactively think about the opportunities and challenges of integrating 3DP technology in the T&A industry and how to effectively incorporate 3DP into the future research and teaching agendas.

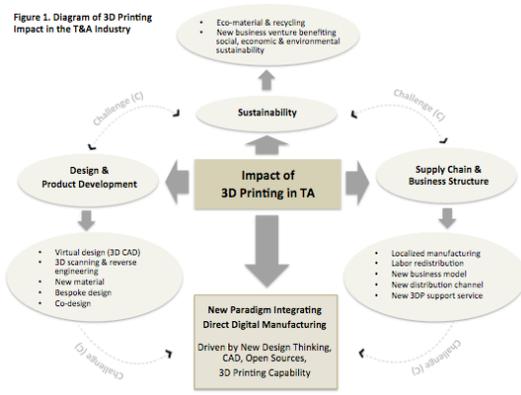
In this conceptual model, there are four fundamental impacting components involved for the T&A industry, including the area of design/product development, supply chain/business structure, sustainability, as well as the new paradigm of integrating direct digital manufacturing (DDM) (Figure 1). First, as for design/product development, the designers would virtually interact with the product in 3D computer-aided design (CAD) program, with which the designers are able to create with unlimited design space and complexity in structure and shape that would potentially produce one complete piece, thus eliminating the traditional processes, such as construction. Also, 3D scanning technology would be employed in the virtual design process to replace the conventional garment fitting procedures using human avatar, and it would encourage the use of reverse engineering method for ease of product modification. The potential capability of mixing and creating various unique materials for 3DP would encourage designers to be more conscious in the overall design process. Further, the concept of bespoke design for various individuals co-designing through collaboration with those individuals who are outside of the T&A industry would become another new trend in the adoption of 3DP technology.

Second, 3DP would largely impact the structure and strategies implemented in the current T&A supply chain and business pattern due to the fundamentally different product development and production process, types of inputs required and pattern of consumption. Because 3DP is highly technology and capital intensive with little involvement of low-skilled labor, developed countries rather than developing countries may enjoy the comparative advantage in apparel manufacturing in the future. When apparel products can be directly printed using 3DP machines, cross-the-

border transportation also can be largely reduced, generating potential cost-saving opportunities both for manufacturers and consumers. Moreover, 3DP technology will also initiate new business model of which consumers can be empowered to self fabricate the final product; thus, it also potentially lead to some alternative distribution channels and new supportive services.

Third, achieving sustainability in the T&A industry is another major impact of applying the 3DP technology and it would mutually affect the previous two factors we have discussed above. Considering the potential vast CAD based design approach and the revolutionary 3DP integrated supply chain, carbon footprints would be reduced, and an immense percentage of inputs such as energy can potentially be saved. Also, due to the 3DP's ability to build objects in only those places where the materials are needed, one of its major advantages is in the reduced production wastes or by-products, which are much like the concept of minimal waste design. In many 3DP processes, the technology allows the reuse of a wide range of materials, and of which some are eco-friendly (Kreiger, et al., 2014). This may inevitably lead to the development of a recycling system for both T&A and non-T&A products and related support business ventures, which would improve all aspects of a sustainable society.

Fourth, the above impacts would ultimately lead to the development of a new paradigm integrating direct digital manufacturing (DDM), which enables 3D physical parts to be produced directly from CAD file. The conceptual model also suggests a set of challenges waiting to overcome for the application of 3DP technology in the T&A industry. For example, designers today will be mostly challenged in developing the skills applying 3D CAD and translating traditional training knowledge into the virtual design environments. Thus, establishing various formats of co-design collaboration with 3D CAD experts will be crucial for designers that apply 3DP. Also, issues such as unskilled labor management and updating current legal systems for intellectual property protection need to be addressed. Beyond the identified impacts and challenges, this conceptual model eventually aims to help lay the ground work for the T&A academic discipline in ways to consider incorporating 3DP into the current curricula and exploring future research topics, including developing 3D CAD interface, 3DP material and skills suitable for T&A design and product development, 3DP based T&A supply chain management and legal framework for 3DP.



### Reference

- Lipson, H., & Kurman, M. (2013). *Fabricated: The new world of 3D printing*. Indianapolis: John Wiley & Sons.
- Kreiger, M. A., Mulder, M. L., Glover, A. G., & Pearce, J. M. (2014). Life cycle analysis of distributed recycling of post-consumer high density polyethylene for 3-D printing filament. *Journal of Cleaner Production*, 70, 90-96.