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Introduction to special collection on 3D printing and wearable technology in fashion

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In fashion combining art, science, and technology, we create designs that push the limits of emerging technologies. 3D printing and wearable technology have experienced an explosion in popularity in the last couple of years in fashion disciplines from both industry and academia. Why now 3D printing has received much attention from consumers, industry professionals, and academic researchers since it was invented almost 30 years ago? Why now wearable technology received much attention in fashion? The increased uses of the Internet of Things, mobile technology, and big data are now allowing new integrations and connectivity of 3D printing and wearable technology in ways previously not possible. As a potentially transformational technology, it is promising that 3D printing and wearable technology will play a more important role in designing and developing personalized fashion-related products in the near future. Much of the scientific research tied with this topic has been conducted in other disciplines; however, limited scientific research has been conducted or published in fashion-related fields.

The objectives of this special collection are to collect cutting-edge knowledge on 3D printing and wearable technology, and applications of these technologies in fashion as well as to envision the future of these technologies when designing and engineering apparel-related products. We are pleased to introduce seven articles (four for 3D printing and three for wearable technology) under this special collection, which were conducted in various countries including USA, South Korea, Sweden, and UK. These articles provide diverse insights of 3D printing and wearable technology in fashion. We hope these seven research papers to be a useful means for designers, product developers, marketers, retailers, and researchers who plan to implement these technologies in their work, and to lead further discussion and research inquiries in these emerging topical areas.

Included in this issue is Sun and Zhao's article, "Envisioning the era of 3D printing: a conceptual model for the fashion industry." The authors of this article proposed a conceptual model to examine the potential impacts and challenges of integrating 3D printing in the fashion industry. They first examined the nature of direct digital manufacturing (DDM) in contrast to traditional manufacturing approaches via conducting literature reviews. A conceptual model applied to DDM integrated fashion industry was then proposed to address this change. In their proposed new paradigm, the authors addressed the direct and indirect impacts of 3D printing in the following four areas: (a) design and product development, (b) sourcing and manufacturing, (c) retail, distribution

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and consumer, and (d) sustainability optimization. The potential challenges of integrating 3D printing in each of these areas were also evaluated. By proposing this integrative model, the authors aimed to help lay the groundwork and explore future research topics and curricula for the fashion industry, particularly with a consideration of 3D printing technology integration that will soon saturate throughout the current supply chain.

In Kwon, Lee, and Kim's article, "Case study on 3D printing education in fashion design coursework, the authors provided a general overview of 3D printing in fashion and its integration in fashion education. They aimed to provide a pedagogical guidance to educators in the fashion discipline by presenting the case of 3D printing implementation in their fashion design course. Rhinoceros (Rhino) and FINEBOT were used for 3D object design and printing. The coursework consisted of lectures including definition and application of 3D printing; training of Rhino use; methods of producing objects; 3D modeling of creative objects; and 3D printing practice. This article included the following five steps to teach 3D printing in fashion, which are consisted of (a) conceptual understanding of 3D printing and its usage, (b) practice of 3D modeling using Rhino tools, (c) practice of 3D object creation, (d) process of 3D fashion object creation, and (e) 3D printing prototyping. A semester-long 3D printing education in the fashion design course called "Digital Fashion Design" provided a valuable learning experience for both the instructor and students, which leads to beneficial insights of 3D printing education. Although challenges for educators were identified when fashion students were learning 3D modeling software, the coursework in this study resulted in increased interest and understanding of the students in 3D modeling and printing of more advanced fashion related objects. This case study focused on the importance of 3D printing in fashion design curricula and the way to strategically integrate this technology into the curriculum.

Next, in the article "Exploration of 3D addictive printing to create sustainable fashion notions and jewelry, Pasricha and Greeninger reported the results of an attempt to apply zero-waste principles to 3D printing in efforts to ensure sustainable applications of 3D technology in the fashion industry. The intent of their study was to develop a design process that minimized waste from 3D printing, ensuring a sustainable process and fashion outcome. The authors used Rhino, Tinkercad, MakerBot Replicator 2 desktop 3D printer, and polylactic acid filament to create elaborative designs such as fashion notions and jewelry. The authors argue that their design research is the first successful attempt at 3D printing for creating biodegradable zero-waste fashion notions and accessories. They employed design thinking and strategies to create objects without the use of rafts and supporters removing waste creation. Multiple attempts resulted in an acceptable outcome of five pendant designs for necklaces, two earring designs, and nine layer-designed buttons. Their work presents a considerable potential to use this disruptive technology in designing and creating fashions that are unique, sustainable, and made on demand.

Consumer acceptance for the use of 3D printed products is another important area of research in 3D printing technology. In Lyn, Hahn, and Sadachar's article "Understanding millennial consumer's adoption of 3D printed fashion products by exploring personal values and innovativeness," the authors examined a hierarchical model of consumer innovativeness in the context of 3D fashion products using a quantitative research design. They aimed to investigate potential predictors of consumers' adoption of 3D printed fashion goods (e.g., personal values, innate innovativeness) and the effects of innovativeness on attitude and intention towards 3D fashion goods in a millennial population. Using a convenience sample, the data were collected through a self-administrated online survey. The results of their study identified personal values as an antecedent of innate innovativeness and found that fashion leadership played a critical mediating role between innate innovativeness and domain-specific innovativeness, in turn developing a positive attitude towards 3D fashion products, which led to intention to use. Although the effect of innate innovativeness on domain-specific innovativeness was only partially supported and no direct effects of personal values on domain-specific innovativeness was found, their findings contribute to existing literature on the technology acceptance model and consumer innovativeness by examining additional predictors. By developing and extending hierarchy model of consumer innovativeness with personal values, this study provides practical insights to fashion retailers by demonstrating how personal values and intention to adopt innovation are linked. According to the authors, to make 3D printed fashion products to consumers, fashion retailers need to pay attention to these consumers who are highly innovative in nature as well as opinion leaders.

In Koo and Fallon's article, "Explorations of wearable technology for tracking self and others," the authors explored designs and functions people like to have in wearable trackers and how these differ between novice and experienced users. Grounded by (a) the unified theory of acceptance and use of technology and (b) technology acceptance model, interviews were conducted with novice and experienced users living in the US, by asking preferred designs and functions of wearable trackers for oneself and others, preferences on sharing the tracked data, and suggestions in designs and functions of wearables. It is recommended to make wearable trackers as accessory types that are small, lightweight, and neutrally colored. Wearable trackers can offer self-tracking of moods and feelings for novice users and self-track physical activities for experienced users. Novice users are more likely to track others' physical health and experienced users preferred to track social media posts of others. Experienced users more reluctant to share their data with others than novice users. The results of this research are beneficial for designers, engineers, and marketers in the process of designing wearable technology.

Chittenden focused her research efforts on "Skin in the game: the use of sensing smart fabrics in tennis costume as a means of analyzing performance," using the secondary data (e.g., visuals). Underlying the surface decoration and cut of contemporary tennis costume is a fabric that enacts its own performance and studies the athlete who wears it. Today, the top players in sportswear companies utilize novel and innovative textiles that enable costume to control and record the temperature, sweat and muscle movement of the performer, whilst also presenting a vehicle to showcase the personality through their aesthetic choices. The use of smart fabrics in sportswear, where the patterns of data collected by the costume visually and numerically display the conditions of the player or performance, holds potential for the ways in which the authors interrogate the interrelationship of clothing and performance across a range of arenas. This article raises questions about the changeable nature of smart clothing and its relationship to the sporting body.

Lastly, in Biswas, Infirri, Hagman, and Berglin's article, "An assistive sleeping bag for children with autism spectrum disorder," the authors successfully designed a wearable, therapeutic device possessing smart textile-based sensors and actuators to treat sleeping disorders among autistic children. A prototype of the designed sleeping bag, integrated with a pressure sensor, a few weighted compartments, and a vibration actuator, was built to detect the awakening stage of the user, and to provide soothing vibratory motions in the form of wearable technology while maintaining the required comfort level for everyday use. Their study well demonstrates how the functionality of a traditional textile based product can be improved by design adaptation for wearable technology. The authors encourage the integration of readily available electronic and computing devices within common textile platforms to administer advanced solutions in the functional product design and development process.

Again, we truly hope these seven research papers to be a useful means for designers, product developers, marketers, retailers, and researchers who plan to implement these technologies in their work, and to lead further discussion and research inquiries in these emerging topical areas.

Authors' contributions
Both YAL and HK carried out this study, participated in the sequence alignment and drafted the manuscript. Both authors read and approved the final manuscript.

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