# The 3D Virtual Technology as an Pedagogical Approach for Teaching Sustainable Apparel Design: Analysis of the ITAA Design Abstract Proceedings from 2015 to 2022

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*Keywords*: 3D virtual technology, sustainable apparel design, apparel pedagogy

**Introduction and background.** Despite the rising significance of sustainable design strategy (Curwen et al., 2013; Gam et al., 2009; Gam & Banning, 2011; Hwang, 2020) and 3D virtual technology in the fashion industry (McQuillan, 2020; Papahristou & Bilalis, 2017), limited studies exist to examine 3D virtual technology as an pedagogical approach for teaching sustainable apparel design. Previous studies have mostly focused on the positive effects of 3D virtual technology as an apparel design and prototyping tool, which can save time and materials at the apparel design and development stage (McQuillan, 2020; Papahristou & Bilalis, 2017). In the fashion discipline, courses covering 'sustainability' subject matters were commonly offered in a lecture style without much studio practices (Baytar & Ashdown, 2014). In addition, previous studies (Abner et al., 2019; Armstrong & LeHew, 2013; Gam & Banning, 2011) implementing sustainability approaches within the studio-based apparel design course were proceeded without the full integration of 3D virtual technology, which aligns with Romeo and Lee's (2013) argument that there are still limited efforts of the new design technology integration into studio-based apparel design courses. Considering that the fashion industry is dramatically moving into the digital transformation waving through the COVID-19 pandemic, it is urgent for the higher education to shift their pedagogical approach well aligning with the current industry demands.

Thus, it is critical to understand the past and current usage of 3D virtual technology in the apparel design curriculum to explore the potential of 3D virtual technology as a pedagogical approach for teaching sustainable apparel design and sustainability issues in general, which is the aim of this study. We analyzed the data from ITAA Design Abstract Proceedings (DAP) over the period of 2015-2022 to understand (a) the past and current usage of 3D virtual technology in apparel design, especially for the use of 3D virtual apparel design software (e.g., Browzwear, CLO 3D, Lectra Modaris, Optitex) and (b) operational and sustainable practices of 3D virtual technology among design scholars.

**Method.** This study conducted a secondary analysis of existing data using the data- and research question-driven approaches (Cheng & Phillips, 2014). The 2014-2022 ITAA Design Exhibition Catalogs (DEC) available electronically were first reviewed before reviewing the primary DAP dataset using the data-driven approach; this initial screening of the total of 1,014 DECs allowed us to come up with two specific study objectives. Then, the total of 586 DAPs, electronically published from 2015 to 2022 through Iowa State University Digital Press were used as the primary data source to fulfill two research objectives. The year 2014 was excluded from this study as DAP did not include the abstracts at the undergraduate and professional level. The 2015-2022 DAP data were used to review keywords, design concepts, processes, techniques, and images of artworks using a content analysis approach.

**Results and discussion.** Among the total of 586 DAPs, 19.3% utilized 3D virtual technology. While the 3D virtual technology usage has been increased from 2015 (9.3%) to 2022 (38.2%), two significant turning points were noticed, which were in 2016-2017 and 2021-2022. In 2017, the 3D virtual technology usage (25.4%) was significantly increased from the previous year 2016 (9.4%). The 2017 data showcased that more design scholars started to utilize 3D virtual technology (e.g., Optitex, Lectra Modaris) for apparel design and Rhinoceros for 3D printing in apparel design (e.g., textiles, jewelry). However, the 3D virtual technology usage was decreased from 28% in 2019 to 18.3% in 2020 and 16.4% in 2021. This might be due to the limited online accessibility of Optitex and other associated technology during the pandemic. The percentage of students using 3D virtual technology in 2017 (38.1%) was higher than that of professionals in 2017 (20%) and students in 2016 (5.8%). However, the percentage of students using 3D virtual technology in 2022 (36.84%) and 2021 (12.1%) were lower than that of professionals in 2022 (41.2%) and 2021 (22.7%), which might be the pandemic effect, argued as fewer students might be able to access and learn 3D virtual apparel design technology through their design coursework during and after the pandemic.

The 3D virtual technology usage for the 2D pattern digitalization was reduced in 2021 (5.5%) and 2022 (9.1%) compared to 2020 (14.1%), while the usage for 360-degree fit checking and simulation was increased from 4.2% in 2020 and 10.9% in 2021 to 29.1% in 2022. Among the total of 113 design scholars who used 3D virtual technology from 2015 to 2022, 51.3% used Optitex, followed by Lectra Modaris (17.7%), CLO 3D (8.8%), and Browzwear (5.3%). Optitex was the most preferred software for many years due to its advanced 2D CAD and early adoption of 2D cloth animation (Hwang & Hahn, 2017) and it was mainly used for digitizing the simple 2D pattern design. However, the use of Optitex was dramatically reduced in 2021 (22.2%) compared to 2018 (72.2%) and 2020 (61.5%), which might be possibly due to the pandemic-related remote learning and the significant growth of other 3D virtual technology options in the fashion industry (Lee, 2022). Design professionals facing limitations with Optitex switched to other 3D software such as Browzwear and CLO 3D for improved accessibility, functionality, drapery design, and integration with other 3D sources to enhance student learning outcomes. The use of Lectra Modaris was decreased to 0% in 2022. In contrast, the usage of CLO 3D was increased from 7.7% in 2020 to 33.3% in 2022, which is close to the Optitex usage (38.1%) in the same year.

In the period from 2015 to 2022, among the total of 586 DAPs, on average, 31.2% (*MIN* = 24; *MAX* = 40; *SD* = 5.5) employed traditional sustainable design methods (e.g., zero-waste pattern-making, natural dye, upcycling) without the incorporation of 3D virtual technology. Although zero-waste approach has been used by design scholars in 2015, zero-waste approach using 3D virtual technology was started since 2019. Among the 231 DAPs from 2019 to 2022, only 3% used zero-waste approach using 3D virtual technology; more specifically, 5.48% in 2022 mentioned zero-waste approach using 3D virtual technology in their DAPs, followed by 2.8% in 2020, 2 % in 2019, and 1.8% in 2021.

**Conclusion.** This study explored the potential of 3D virtual technology as a pedagogical approach for teaching sustainable apparel design. Despite the uptrend of 3D virtual technology

usage, the findings revealed that very limited apparel design educators use 3D virtual technology as a pedagogical tool, especially in the context of sustainability practices such as zero-waste design. The study also presented that CLO 3D is the rising software for remote learning and multi-purpose apparel design for the past couple of years. The data used in this study only pertained to a portion of design scholars who are ITAA members and the design scholarship published through the 2015-2022 ITAA DAPs, which are the main limitations of this study. Thus, future studies should examine how a broader range of apparel design educators use 3D virtual technology in design courses and its integration with sustainable apparel design approaches. Despite the limitation, this study is unique to bring apparel design educators' attention to the needs of integrating 3D virtual technology with sustainability practices in their apparel design curriculum. In order to align with the current industry workforce demands, apparel design educators need to play a crucial role to prepare students with new talents of 3D virtual technology. We as the educator also need to be ready for learning new design technologies and willing to fully implement those into the curriculum.

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