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Modular Fashion Design for Sustainability: Integrating a CLO3D Digital Library with Physical Prototyping for Versatility in Product Development

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Abstract

The fashion industry generates significant environmental impact through overproduction and the short life cycles of clothing products. Modular design, which allows multiple wearing configurations from a single product through removable and interchangeable components, represents a promising sustainable alternative but lacks standardized methodologies that integrate digital innovation with physical production. This study develops and validates an integrated methodology for creating versatile modular clothing products. Based on the three-dimensional framework of modularity (structure, function, and system), four categories of modular elements were defined and organized in a CLO3D (Version 2026.0.202; CLO Virtual Fashion Inc., Seoul, Republic of Korea) digital library. Combinatorial calculation generated 360 theoretical variants, of which 24 were selected as structurally and aesthetically feasible. A physical prototype consisting of a vest, four modules and three sleeve variants was made from 100% linen fabrics (290 and 180 gsm) with snap fastener tape and natural shell buttons. The digital–physical visual comparison confirmed high concordance for proportions and alignment of the modules, with limitations in simulating the fabric drape. The 24 validated configurations demonstrate that a single modular clothing product can function as an effective wardrobe multiplier. The study confirms that integrating the CLO3D digital library with physical prototyping from sustainable materials constitutes a viable and replicable methodology in the fashion industry.

Keywords: modular fashion design; sustainable clothing; CLO3D; digital prototyping; versatile products; circular economy; digital library; sustainability

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