

Eco-Conscious Design Process: Natural Dyed Knitwear with Innovative 3D Motifs

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Background

The global knitwear market was valued at over \$582.5 billion (USD) in 2021 and is expected to almost double within the next ten years (BusinessWire, 2022). This can be attributed to the versatility and practicality of knitwear in a consistently changing market. Interest in e-commerce and online buying has grown too, allowing for smaller brands and new designers to break into the knitwear market with their original designs, and improve the way the knitted garments are made. However, synthetic dyes used in the coloration of yarns and knitwear contribute to the pollution of water bodies and soil due to the discharge of colored effluents during the dyeing process (Islam et al., 2022). Research indicates that textile dyeing is one of the most polluting industrial activities, with effluent treatment facilities required to mitigate the environmental risks associated with untreated wastewater discharge (Islam et al., 2022). The new generation of knitwear designers must consider and address these challenges when initiating a new design process (Ravnløkke, 2021).

Traditional knitwear cut-and-sew design leads to significant waste, with cutting and sewing processes accounting for approximately 50% of waste generation (Tanvir & Mahmood, 2014). Modular design systems offer a transformative design approach characterized by small, standardized units (motifs) that can be combined in diverse configurations to achieve various forms and functionalities (Chen & Lapolla, 2020). Fully fashioned garments with modular design elements offer a sustainable alternative to traditional knitwear construction methods, allowing for the customization and reconfiguration of garments for different aesthetic needs without generating excess waste (Yao et al., 2021).

This undergraduate Summer Scholar research project is a creative investigation aimed at demonstrating the feasibility of producing eco-conscious knitwear that prioritizes environmental sustainability without compromising on innovating aesthetic appeal or functionality. The knowledge through practice methodology guided the development of a modular sweater on a flatbed knitting machine (Bye, 2010; Stevenson & Meakin 2024). By looking for new innovative approaches to material selection, dyeing processes, and garment construction, this project seeks to inspire broader adoption of sustainable practices within the fashion industry.

Method and results

A Silver Reed SK840 standard gauge knitting machine was used, and the needle size determined the yarn size selections. The conceptual inspiration was derived from the octopus, reflecting its organic patterns and red-orange hues in the color of the yarns and the shape of the repeating 3D motif. Sustainability was prioritized through the entire hierarchy of the knitted garment design process, from fiber and yarn selection to fabric design and assembly stages. The first stage consisted of the collection of materials, primarily sourced from upcycled sweaters purchased from second-hand stores such as Goodwill. By repurposing these garments, the project reduced waste and minimized the environmental impact of the materials used. Yarns were extracted from these sweaters by unraveling them and categorizing them by fiber type: cotton, acrylic, and wool. Aiming to dye the yarn in a natural dye bath, a natural fiber had to be selected, eliminating acrylic as a suitable option. Evaluating properties of cotton and wool fibers led to cotton to be selected for this project, because cotton does not felt when

subjected to heat and friction in the dye bath, and because of its abundance in the textile market (Textile Exchange, 2023).

Natural dyeing techniques were used to create custom colors for two cotton yarns selected. Beets and coffee were utilized as natural dye sources, providing rich and earthy tones while avoiding the use of harmful chemicals commonly found in synthetic dyes (Affat, 2021). A salt and vinegar solution was used as a pre-mordant for the dyes to keep water contamination to a minimum (Repon et al., 2017). The resulting muted red color with natural hue variations is reminiscent of the octopus's natural patterns. Moreover, the integration of elements of the natural world into the fabric of the garment, connects the wearer to the environment, creating emotional attachment and preventing disposal of the product (McNeill et al., 2020).

The knitting process started by analyzing the octopus tentacles and creating 3D motifs using the short rows technique. Inspired by the work of Chet Lo, a London-based designer (Subair, 2021), over 50 motifs were created in four different sizes, followed by draping experimentation with placement and size variations on a size 8 dress form. A nonbinary silhouette that can be flipped front to back was constructed, using seven fully fashioned panels including two sleeves, two front panels, and three back panels. Special attention was given to motif placement to ensure cohesion with the concept, durability through wear, longevity through laundering, and a comfortable fit. Tight hand-stitching of all pieces with a chain hand-stitch ensured that the modules could later be undone and re-assembled if desired, by inserting the 3D motifs between any seams (Figure 1). The rolling edges of the plain knitting panels offer unity with the 3D motifs and reveal the back of the fabric that forms additional color patterns.

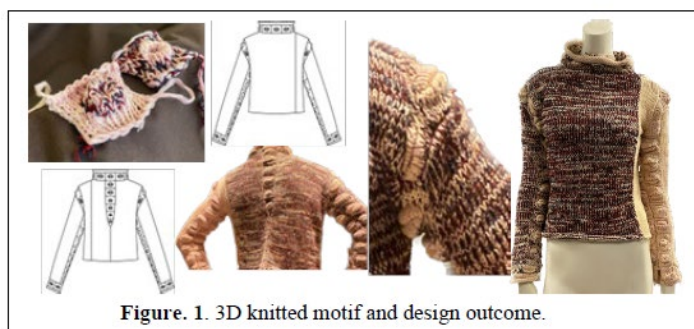


Figure 1. 3D knitted motif and design outcome.

By combining traditional hand-mending techniques with modern machine knitting principles, the researcher highlighted the project's broader commitment to sustainability and environmental consciousness, aiming to encourage the wearer to consider giving 'an endless life' to the garment (Montenegro & Montenegro, 2023; Healy & Bigolin, 2010).

Significance

By integrating upcycled materials, natural dyeing, innovative 3D machine-knitting, and sustainable assembly techniques, the design process explored in this project achieved a balance between aesthetics and environmental consciousness. Through its emphasis on sustainability, creativity, and innovation, the project represents a hands-on approach to training the new generation of fashion designers, by prompting multiple investigations into sustainable practices that go beyond the use of knitting technologies. By challenging the current practice of knitwear design and construction, which often promotes a digital integration of all stages, this project pushes the boundaries of what the design output should be within the realm of eco-conscious knitwear, offering new insights and possibilities for the future of sustainable fashion.

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