

One-Piece Flat Pattern for Printed Beachwear Cover-Ups to Minimize Cut-and-Sew Waste and Achieve Sustainability

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Waste minimization
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ABSTRACT:

Cover-ups are a type of garment worn to the beach or an informal social event. They are attractive, convenient, easy to wear, and functional. It should be wrinkle-resistant, lightweight, and keep the wearer cool and comfortable besides its aesthetical properties. This work focuses on achieving sustainability in designing and producing printed beachwear cover-ups, from the one-piece flat pattern to the final product. The designs balanced aesthetics, patternmaking, and fabric waste for sustainable, innovative garment pieces. The geometric one-piece flat pattern is a way to reduce fabric waste during cutting by utilizing as much fabric area as possible. The work combines crochet, a traditional handicraft, with contemporary digital crafts to produce printable digital designs with sustainable values. Adobe Photoshop capabilities have been employed to create printing patterns utilizing the photos of the previously implemented handmade crochet motifs. The printing designs were applied to a single jersey knitted fabric (80% Polyester – 20% Spandex) by sublimation printing.

The specialists in the clothing and textile domain evaluated the proposed nine beachwear cover-ups produced in this work. The questionnaire was designed to evaluate motif quality, design foundations, flat pattern making, the amount of fabric waste, and the final product. The responses to the questionnaire were statistically significant on the success of the proposed designs in minimizing cut-and-sew wastes and creating innovative printed beachwear cover-up products that attain sustainability.

1. Introduction

A cover-up is generally used to bridge the gap between being fully dressed and wearing a swimsuit which can be worn to the beach or an informal social function (McMahon, 2022). The beachwear cover-up eliminates the need to find a way to change swimsuits into regular clothes on the beach by providing an attractive, convenient, and functional alternative (Catalonia, 2022), in addition to sun protection, wind and sand on the beach and worn to show more modernity (Rodriguez, 2022). The cover-up must help the wearer to feel comfortable and not provide much warmth to the body. Besides, cover-ups also should be easy to wear, practical, versatile, wrinkle-resistant, and light enough to take everywhere. The human body can be covered with a cloth wrap by tying it around the waist, draping it over the shoulders, or wearing it across the body (Miller, 2022). Cotton, linen, polyester chiffon, and polybutylene terephthalate are prevalent beachwear textiles. Cotton fabric offers cooling characteristics and excellent skin protection, but these cover-ups can be heavy and wrinkled (Miller, 2022). Linen fabrics are smooth, comfortable, and temperature-regulating (Suyambulingam, et al., 2022). Chiffon or Polyester are popular since they are lightweight, wrinkle-proof, and foldable.

In this work, the authors innovated beachwear cover-up designs of one-piece flat patterns with minimal cuts to benefit as much as possible from fabric width to minimize waste. These designs also are seams free and have no closures. Instead, they are worn by wrapping them around the body or tying the fabric ends into knots. The one-piece method helps to offer unexpected and creative design ideas and reduce cut-and-sewn waste.

2. Statement of Problem

Achieving sustainability throughout the production process of the suggested fashionable beachwear cover-ups, from creating the one-piece flat pattern to the final product.

3. Objectives

- Creating one-piece flat patterns to minimize fabric waste.
- Merging handicrafts with digital crafts to create sustainable values for printable digital designs.
- Printing fabrics through sublimation printing to reduce water and dye/chemical waste to preserve the environment and attain sustainability.
- Using knitted fabric as it preserves its shape after cutting, eliminating the sewing and finishing additional steps, besides its ability to wrap and tie without the need for closures.

4. Significance

- Preserving the environment and achieving sustainability by minimizing cut-and-sew wastes.
- Use Adobe Photoshop for innovative printing designs as one of the most important programs in various technical fields.
- Combining handicrafts with digital crafts for creating contemporary textile printing designs.

5. Theoretical Framework

Recently, the concept of "design for waste minimization" encourages designers to produce less wasteful designs or to explore alternatives to traditional designs that produce no waste. Cut-and-sew waste is the unused fabric from gaps and unused spaces between pattern pieces (Enes & Kipöz, 2020). Professionals in garment design must combine creative patternmaking technologies, aesthetics, and fabric waste reduction (McKinney, et al., 2020). Patternmaking involves shaping a flat fabric to fit one or more body curves (Naznin, et al., 2017). Fabric is the most valuable component in waste reduction in the garment industry. Cut-and-sew waste is the most critical pre-consumer waste category (Yalcin-Enis, et al., 2019) since it accounts for roughly half of the garment costs (Bilgiç & Baykal, 2017). Pattern pieces are put as

near as possible on the fabric width as a marker to minimize fabric waste in a conventional multi-piece pattern cutting. Due to the irregular forms of pattern pieces, it is hard to employ cloth properly in marker making. Previous studies found that even with the best marker-makers and software, 10–20% of adult outerwear clothing is wasted (Feyerabend, 2004). Other studies showed that approximately 80%-85% of the fabric is used (Townsend & Mills, 2013). However, Fabric consumption depends on garment type, size, the number of pattern pieces, and marker-maker or software proficiency (Lei & Li, 2021).

Garment design concerning fabric width is the most constrained categorization for the waste produced in the garment industry; thus, these restrictions can inspire innovation (McQuillan, 2019). When making an item of clothing using the flat pattern-cutting method, a zero-waste method will utilize the whole width of the fabric (Townsend & Mills, 2013). This technique was developed to reduce fabric waste by creating pattern pieces that entirely use the fabric and profoundly impact the garment's design. Working with geometric pattern shapes is a way used to eliminate fabric waste in the garment design and construction process (Orzada, 2017). However, minimizing waste in clothing is not a novel idea. The sari, the kimono, and the Greek chiton are all examples of clothes that adhere to zero-waste production principles. These time-tested garments have created innovative manufacturing approaches that generate no waste (Almond, 2018).

In the process of clothing design, inspiration plays a significant role. In various ways, designers incorporate their sources of inspiration into their works (Çinar, 2017). The crochet motifs have inspired innovative digital designs for printed scarves (Abou Hashish & El Zean, 2022). The Hyperbolic Crochet Coral Reef was a worldwide collective making material replicas of marine life and evolutionary theories (Roosth, 2013). Also, artists whose work intersects art, math, and science produced a hyperbolic crochet installation

to represent coral reefs (Wertheim & Wertheim, 2015). Crochet is used for making hyperbolic configurations inspired by ocean mathematical art (Meyer, 2020).

Crochet is a textile handicraft that can only be done by hand or with a needle hook (Sehdev, 2020) (Karp, 2018). Crochet is easy to learn and versatile (Abou Hashish, 2017). A crochet motif is a piece of crocheted fabric that may be used alone or repeated to form larger designs for various uses (Hatta, 2020). It consumes small amounts of yarn (Eckman, 2012). The crochet motif can be made in many shapes using one or more colors and stitches (Eckman, 2008).

Digital technologies significantly affect the future by creating sustainable values in many aspects (Casciani, et al., 2022). It allows people to expand their hand works through digital media and transfer it to various formats (Rosner, et al., 2014). Digital crafts are the other face of the handicrafts employed in the design process within the virtual realm. It provides new aesthetic perspectives on the form and surface of fabrics (Bailey & Townsend, 2015) and preserves handicrafts in intangible dimensions (Zabulis, et al., 2020). Utilizing computer-aided design (CAD) software facilitates textile design. Using photos for printed textile designs improves and provides a distinct image representation style (Nimkulrat, et al., 2016). It is anticipated that combining traditional handicrafts with digital crafts would generate practical and futuristic design concepts for printed fabrics that are new and unexpected (Nimkulrat, 2020). Sublimation transfer is the most prevalent method for digital printing on synthetic textiles that are either 100 percent polyester or at least 60 percent polyester for optimal results. It is the simplest and most versatile way to apply designs to textile fabrics (Sarkodie, et al., 2017). Compared to conventional printing, the most significant advantage of digital printing is its high productivity with less water use and waste of dyes and chemicals (Raja, et al., 2019).

6. Methodology

This work follows the experimental, analytical method; it aims to innovate printed beachwear cover-ups of one-piece flat patterns without seams to fit various sizes. The suggested patterns were drawn by Photoshop in actual dimensions and saved as digital files. Crochet motifs inspired by the seaside and ocean creatures have been made manually with yarn and hook, then photographed to convert them to digital files PNG. The digital motifs were then used to make a design repeat to fill the cover-up pattern previously made. The sublimation printing method applied the knitted fabric's cover-up patterns with print designs. Finally, the specialists evaluated the motifs' quality, design foundations, suggested patterns, the fabric used, and final printed beachwear cover-ups, and then the data collected was analyzed and discussed.

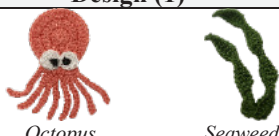

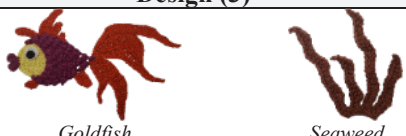
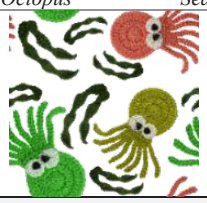

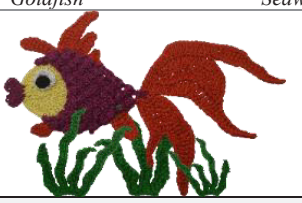


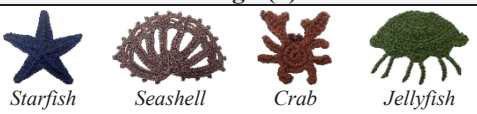




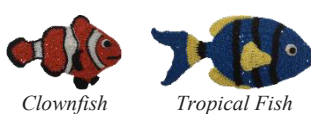


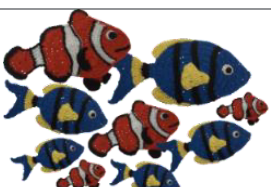

6.1. One-piece flat pattern preparation

The work started by creating flat patterns with actual dimensions in Adobe Photoshop. Each pattern was saved as a PNG file to facilitate applying the printing designs. Every one-piece flat pattern focused on exploiting the width of the cloth in the best possible way through geometric shapes to minimize fabric wastes, considering the diversity of the shapes so that each piece would be unique in shape and the way of wearing. For some designs, the leftover fabrics from the cutting stage were cut straight and used to make accessory belts that tie the waist.

6.2. Crochet motifs implementation

All motifs were handmade with a crochet hook size 3.25 mm and 100% Cotton yarn produced by Misr for Dyeing and Processing Company, Bright © (Anon., 2022). Motifs were all inspired by seaside life and ocean creatures.

Table 1: Crochet motifs and pattern repeats for the suggested printing designs

	Design (1)	Design (2)	Design (3)
Crochet Motif	 <p><i>Octopus</i> <i>Seaweed</i></p>	 <p><i>Coral</i></p>	 <p><i>Goldfish</i> <i>Seaweed</i></p>
Pattern Repeat			
	Design (4)	Design (5)	Design (6)
Crochet Motif	 <p><i>Sea Leaf</i> <i>Seahorse</i> <i>Starfish</i></p>	 <p><i>Small Fish</i></p>	 <p><i>Starfish</i> <i>Seashell</i> <i>Crab</i> <i>Jellyfish</i></p>
Pattern Repeat			
	Design (7)	Design (8)	Design (9)
Crochet Motif	 <p><i>Dolphin</i> <i>Starfish</i></p>	 <p><i>Clownfish</i> <i>Tropical Fish</i></p>	 <p><i>Ship</i> <i>Anchor</i></p>
Pattern Repeat			

6.3. The printing design preparation

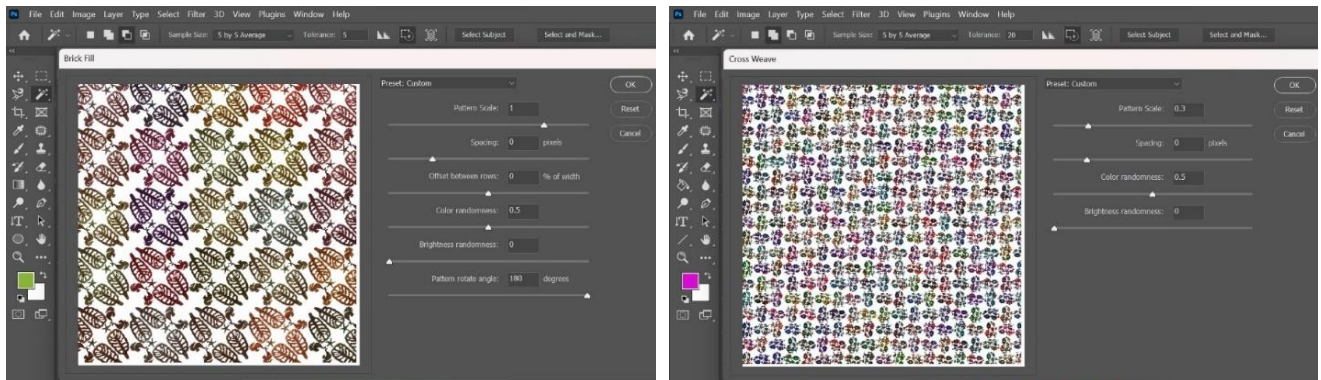
The crochet motifs were photographed to convert to digital files, processed using Adobe Photoshop, and saved as PNG digital files. Digital motifs were used to design the pattern repeats for textile printing.

Table 1 shows the digital format of the crochet motifs and the repeat patterns for the suggested printing designs. In designs (1), (2), (7), and (9), the crochet motifs were arranged to make an offset repeat pattern for seamless designs. While in designs (3), (4), (5), (6), and (8), the crochet motifs were collected in a design that repeats in a specific configuration. Each repeating pattern was defined in Adobe Photoshop and arranged in brick fill and cross weave patterns, as shown in the filling pattern examples in figure 1. The printing designs were applied to fill the pre-saved digital cover-up flat patterns with actual dimensions in Photoshop and saved as PDF files to be ready for sublimation printing onto fabric.

6.4. Fabric and printing method

This work used white, single jersey knitted fabric (80% Polyester – 20% Spandex) in 140 cm width. Knit fabrics have become the most popular source of fashion worldwide (Amin & Mahmud, 2020). The knitted fabric edges can be cut and left without sewing as the looped structure prevents edges from tensile deformation (Dash, et al., 2022). Polyester and Spandex are two common materials for swimsuits and beachwear used for their advantages; Polyester has wrinkle-resistance properties, consistent appearance, excellent wicking, and moisture transfer (Özkan & Kaplangiray, 2019). Spandex (elastane) is the most significant commercial elastomer (Meredith, 2004). It is wrinkle-resistant, like Polyester, and has higher flexibility for an elegant appearance (Mather, 2015).

The proposed cover-up designs were printed onto the knitted fabric through sublimation which works well with polyester/spandex blends, especially when the polyester fiber ratio is high (Özomay & Özomay, 2021) (Sarkodie, et al., 2017).



(a) The brick fill pattern of design (4)

(b) The cross-weave pattern of design (8)

Figure 1: The filling patterns from Adobe Photoshop

6.5. Final products

Nine designs of one-piece flat patterns for beachwear cover-ups have been printed through the sublimation printing method. After printing, each design was cut along its outline to separate it from the rest of the fabric, leaving a small amount of fabric waste, and then the cover-ups were ready to be worn. Photos of the cover-ups were taken with the cooperation of a professional fashion model, and the model gave her consent for the photos to be used and published. During the photo shoot, the model demonstrated

various ways the printed one-piece cover-ups could be worn.

Figure 2 shows the one-piece flat pattern dimensions, the flat pattern after adding the printing design, and the final cover-up of the design (1). The very pale-yellow color has been used as a background. This design is a backless, long V-neck cover-up wrapped around the body with straps formed by tying the fabric edges above the shoulders. The A points are tied together on the left shoulder, and the B points are on the right shoulder.



Figure 2: Design (1) Shoulder-tied wrap

Figure ٣ shows the one-piece flat pattern dimensions, the flat pattern after adding the printing design, and the final cover-up of the design (٣). The printing design has diagonal lines in the background of two solid colors, pure blue and very pale cyan. The

cover-up design is rectangle-shaped and worn in two ways. It can be worn as a sarong by tying A and B points around the waist. Otherwise, it may be wrapped across the neck and tied at the back as a halter dress.



Figure 3: Design (2) Halter/Sarong

Figure 4 shows the one-piece flat pattern dimensions, the flat pattern with prints, and the final cover-up of the design (3). the background of the printing design is a very pale red color. The outline frame and the neckline are made of two parallel lines

of pure orange and dark pink colors. It is a poncho or kaftan cover-up with a V-shaped neckline and a slit in the middle of the garment. The edges are curved symmetrically.

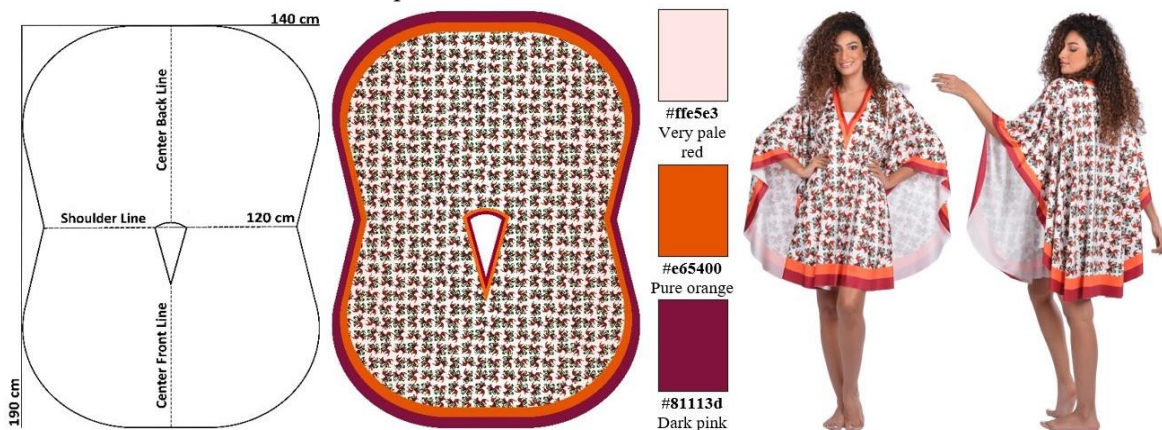


Figure 4: Design (3) Poncho/Kaftan

Figure 5 shows the one-piece flat pattern dimensions, the flat pattern with prints, and the final cover-up of the design (4). A moderate green color has been used for the background after decreasing the opacity by 30%. This design is a side tie cover-up skirt with a circular waistline and an open center front. The skirt hangs smoothly from the waist by



Figure 5: Design (4) Side tie skirt/One-shoulder dress

Figure 6 shows the one-piece flat pattern dimensions, the flat pattern with prints, and the final cover-up of the design (5). The printing pattern is repeated on a very soft blue background and is framed with a very dark blue colored line. It is an asymmetrical tied cover-up skirt. The circular waistline makes the skirt hang smoothly around the waist without darts, pleats, or gathers. When the

fabric ends, A and B, are tied together at the center front, the right side will be approximately mid-thigh, while the left side will be approximately low-calf. When the two ends of the fabric are tied together at the left side, the front of the skirt will be approximately mid-thigh, while the back will be approximately low-calf.

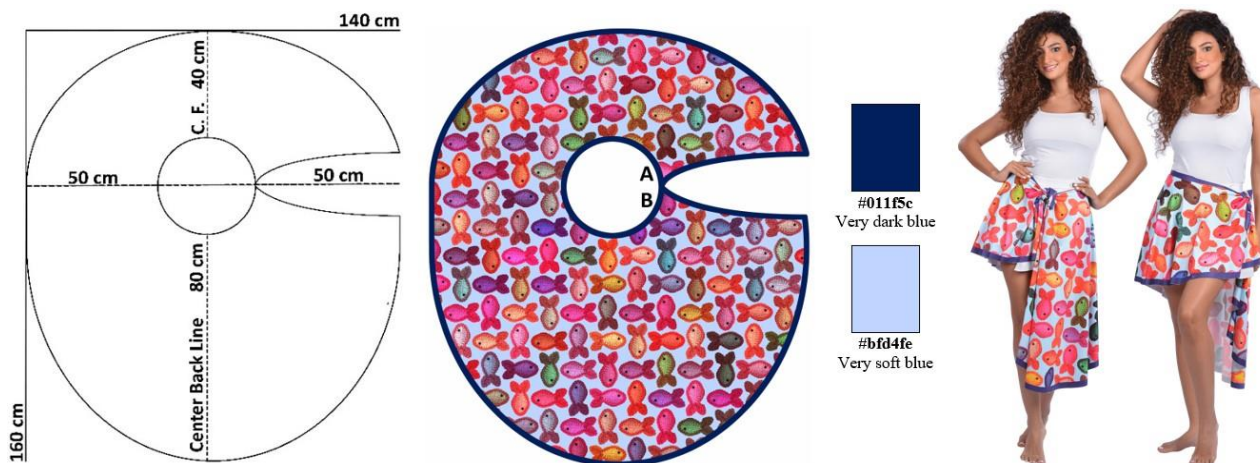


Figure 6: Design (5) Asymmetrical tied skirt

Figure 7 shows the one-piece flat pattern dimensions, the flat pattern with prints, and the final cover-up of the design (6). The background of the printing pattern is a gradient color of very soft yellow and lime green colors. The pattern is framed with a

dark lime green color. It is pants made of two identical flat pattern pieces cut opposite each other. This cover-up design has only one seam line at the crotch to link the two pieces together. For wearing pants, the crotch line is held between the legs so that

the short crotch length is at the center front and the long crotch length is at the center back. The two A points of the front are wrapped around the waist and tied at the back. Then, the two B points of the back are wrapped around the waist and tied at the front. The outside legs of the pants were left open. This

design can also be worn as a jumpsuit by tying the two A points around the neck and then wrapping the two B points around the waist and tying them at the front. The size of this design can be enlarged by increasing the pattern width and crotch depth.

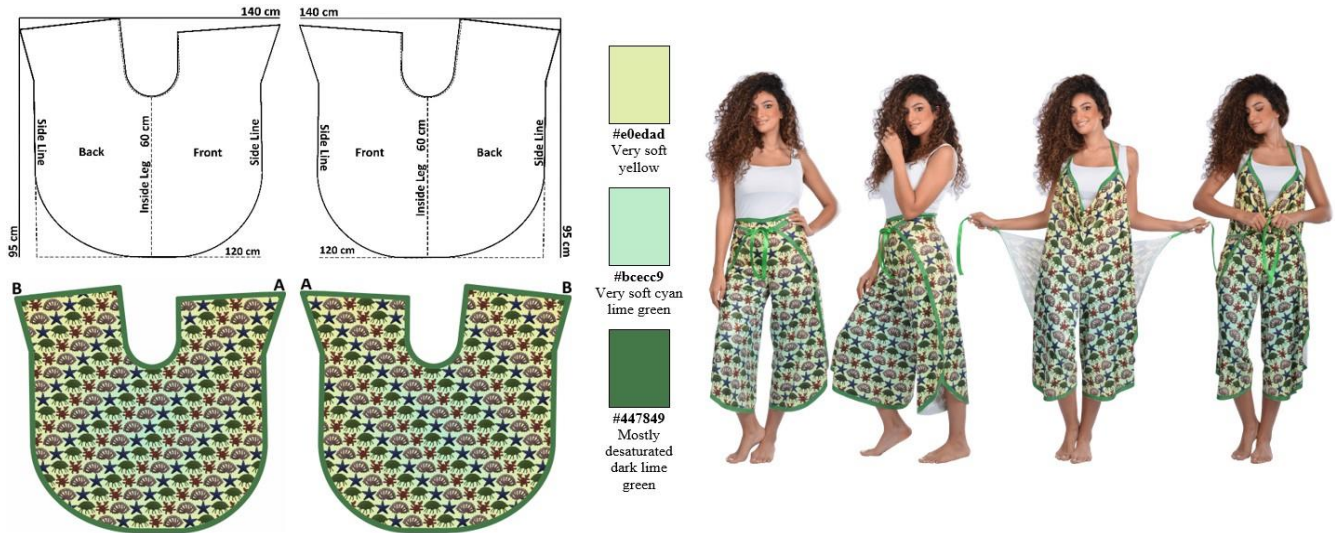


Figure 7: Design (6) Wrap pants/Jumpsuit

Figure 8 shows the one-piece flat pattern dimensions, the flat pattern with prints, and the final cover-up of the design (7). The background of the printing design is a light greyish blue. It is a bib-like cover-up dress worn by inserting the head into the neck opening at the center so that the rounded hem

will be at the front and the rectangular hem at the back. The long ends A and B at both sides are wrapped from the back around the waist, then tied at the front. The dress has a decoration slot on both shoulders.

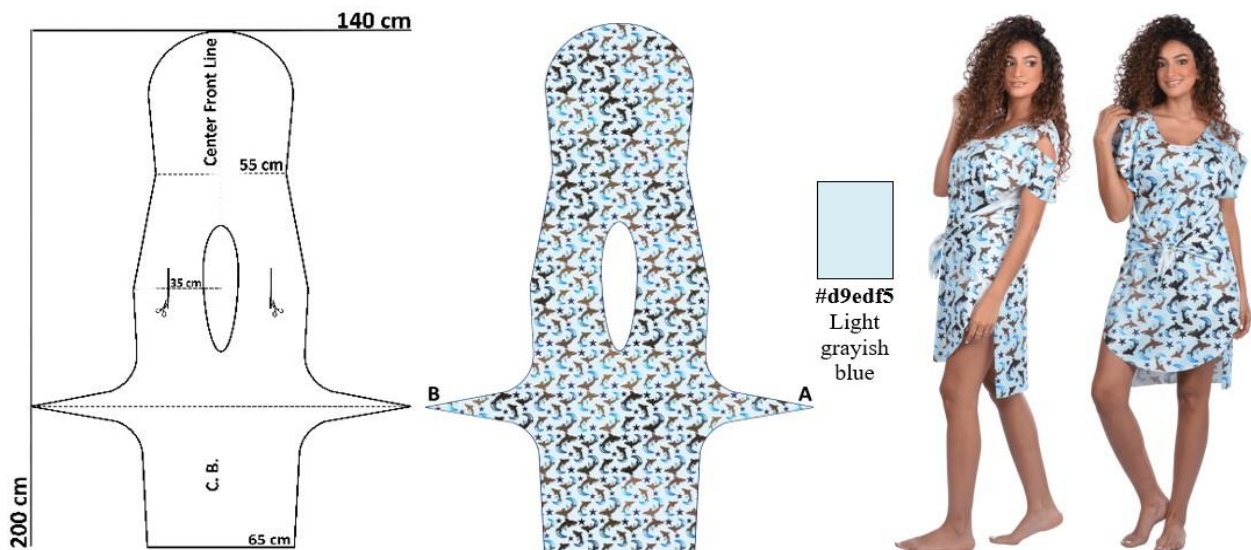


Figure 8: Design (7) Bib-like dress

Figure 9 shows the one-piece flat pattern dimensions, the flat pattern with prints, and the final

cover-up of the design (8). The background of the printing design is a mix of colors soft yellow, pale

orange, lime green, light cyan, soft magenta, soft red, light blue, and dark blue. It is a one-shoulder tropical dress. This dress holds onto the left shoulder by tying the two A points together. The dress is wrapped

around the body and has two knots at the right sideline formed by tying the two B points together and the two C points together.

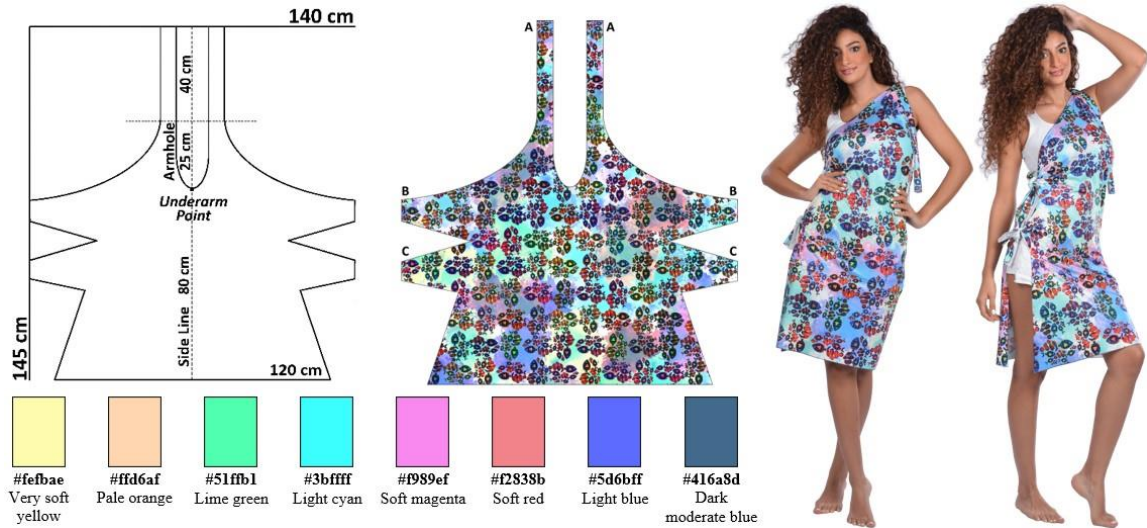


Figure 9: Design (8) Tropical dress

Figure 10 shows the one-piece flat pattern dimensions, the flat pattern with prints, and the final cover-up of the design (9). The background of the printing pattern is a gradient color of light grayish blue and very soft blue colors. The design is framed

in a very dark blue color. It is a circular cardigan cover-up design. It is sleeveless with two slots for arms and a shawl collar. The cover-up cardigan is open at the front but may be more secured by wearing an external belt.



Figure 10: Design (9) Cardigan

7. Results and Discussion

The printed designs, flat patterns, and final products in this work were evaluated using a rubric questionnaire (Google Forms) based on three primary axes for each design as follows:

First axis: Motifs quality and design foundations:

- Topic 1.** The creativity of the Crochet motifs.
- Topic 2.** The yarn suitability (type & thickness).
- Topic 3.** The crochet motifs implementation quality.
- Topic 4.** Achieving the design elements (lines - shape - texture - color - space).

Topic 5. Achieving the design principles (rhythm - harmony - proportionality - focus - balance).

Topic 6. The effectiveness of using computer capabilities in the printed design.

Second axis: The flat pattern and the fabric:

Topic 7. The flat pattern outline helped to reduce waste from cutting.

Topic 8. The printed design is unaffected by wearing style.

Topic 9. The suitability of using knitted fabric.

Topic 10. The implementation method reduced sewing and finishing costs.

Third axis: Final product:

Topic 11. The printed design suits the final cover-up design.

Topic 12. The product matches contemporary fashion trends.

Topic 13. The final product achieves distinction and innovation.

Topic 14. The final product is marketable.

Fifteen specialists in the clothing and textile domain from Egyptian universities responded to the questionnaire. The responses were rated according to Likert's five-point scale: very poor (one point), poor (two points), fair (three points), good (four points), and excellent (five points). The response percentages for each topic of the three axes of evaluation of the proposed designs are shown in Table 2.

According to the specialists' responses, figure 11 shows the percentages of topics on the first axis, regarding motifs quality and design foundations. It is noticed that the crochet motifs innovatively succeeded in expressing the seaside and ocean creatures in all designs, especially designs (3), (6), and (8). The implementation method of the crochet motifs suits designs (3) and (6) the most, while they were perfectly implemented in design (3). Furthermore, design (7) received the highest percentage in achieving the design elements, while design (6) highly achieved the design principles. The designer successfully employed and used computer capabilities in all printed designs, especially designs (3) and (6).

Table 2: The percentages of the three axes of the questionnaire topics according to the specialists' responses

		Design (1)	Design (2)	Design (3)	Design (4)	Design (5)	Design (6)	Design (7)	Design (8)	Design (9)
First Axis	Topic 1	89.33	78.67	93.33	92.00	92.00	93.33	90.67	93.33	92.00
	Topic 2	89.33	85.33	94.67	92.00	93.33	94.67	93.33	93.33	92.00
	Topic 3	94.67	88.00	100.00	96.00	96.00	96.00	93.33	97.33	96.00
	Topic 4	86.67	80.00	92.00	86.67	90.67	92.00	93.33	84.00	92.00
	Topic 5	89.33	78.67	92.00	88.00	90.67	93.33	92.00	85.33	90.67
	Topic 6	90.67	81.33	92.00	86.67	88.00	92.00	89.33	88.00	90.67
	Average	90.00	82.00	94.00	90.22	91.78	93.56	92.00	90.22	92.22
Second Axis	Topic 7	94.67	96.00	96.00	88.00	90.67	93.33	81.33	84.00	92.00
	Topic 8	93.33	93.33	98.67	90.67	93.33	96.00	93.33	92.00	96.00
	Topic 9	93.33	89.33	97.33	90.67	90.67	94.67	90.67	89.33	97.33
	Topic 10	96.00	94.67	94.67	90.67	90.67	94.67	85.33	86.67	96.00
	Average	94.33	93.33	96.67	90.00	91.33	94.67	87.67	88.00	95.33
Third Axis	Topic 11	89.33	86.67	97.33	90.67	96.00	97.33	96.00	92.00	93.33
	Topic 12	93.33	82.67	94.67	84.00	94.67	96.00	94.67	90.67	92.00
	Topic 13	86.67	78.67	93.33	85.33	93.33	96.00	93.33	90.67	92.00
	Topic 14	92.00	85.33	97.33	88.00	94.67	97.33	94.67	92.00	92.00
	Average	90.33	83.33	95.67	87.00	94.67	96.67	94.67	91.33	92.33

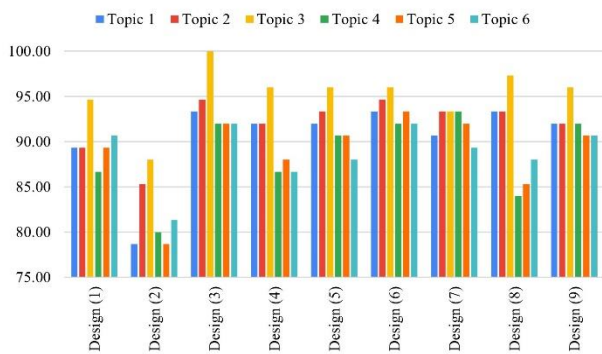


Figure 11: The percentages of the first axis topics according to the specialists' responses

According to the responses' percentages for the second-axis topics concerned with the flat pattern and the fabric used, figure 12 indicates that flat patterns (2) and (3) reduced cutting wastes. It also shows that the wearing style did not affect the final cover-up's printed design. Using the knitted fabric has a prominent effect on the final product appearance without seams for all designs, mainly designs (3) and (9). The implementation method for all products helped save sewing and finishing costs.

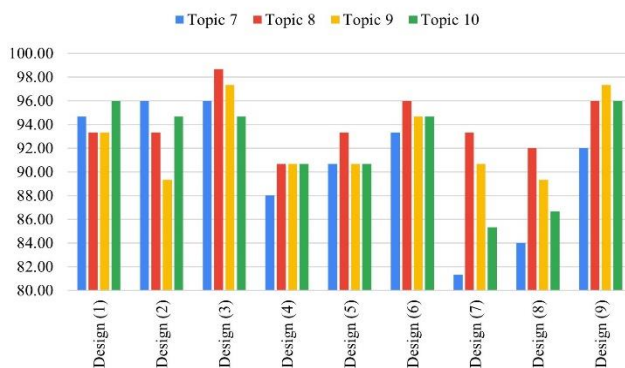


Figure 12: The percentages of the second axis topics according to the specialists' responses

The responses for the third axis, concerned with the final product evaluation, are shown in figure 13. Designs (3) and (6) had the highest rating in the suitability of the printed designs with the final product appearance. Most agreed that design (6) aligns with contemporary fashion trends and achieves excellence and innovation. Designs (3) and (6) were regarded as highly marketable final products.

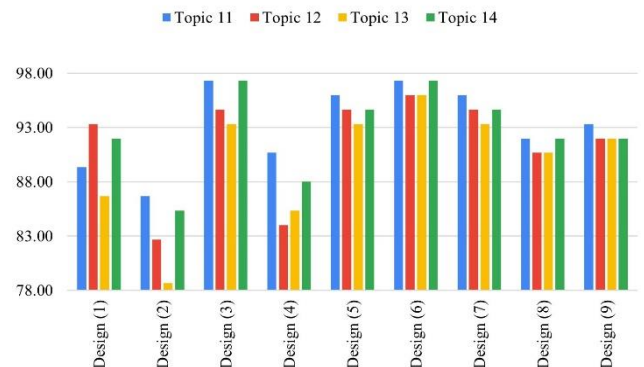


Figure 13: The percentages of the third axis topics according to the specialists' responses

The percentages average of each design on the three axes are represented in figure 14. These collected results indicate the superiority of the design (3) regarding motif quality, design foundations, flat pattern, and printed fabric appearance. At the same time, design (6) is highly accepted as a final product.

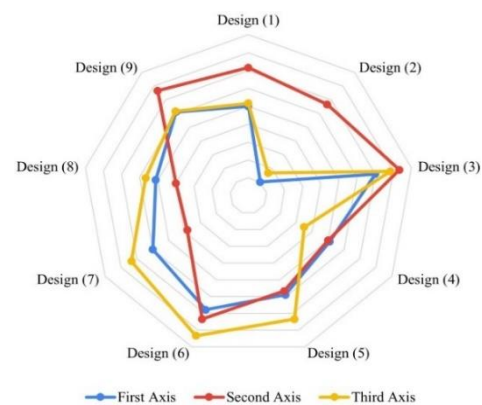


Figure 14: The percentages average of designs evaluation on the three axes

Table 3 shows the standard deviation of the three evaluation axes according to the specialists' responses. The results have statistical significance in the extent of consensus or divergence of opinions on the various topics of the three axes of the questionnaire for the proposed designs. The lower the standard deviation, the more it implies an agreement on the questionnaire topic and vice versa.

The standard deviations of the first axis topics of the evaluation concerned with motif quality and design foundations are shown in figure 15. It was found that the specialists' consensus on design (3) in terms of the innovation and creativity of the crochet motif and the suitability of the yarn type and thickness. The zero value of the standard deviation for design (3)

indicates the consensus on the quality of the implemented crochet motif. Designs (1), (4), and (7) achieved the design elements, while most opinions

agreed that design (6) highly achieved the design principles. Also, the designer successfully used computer capabilities for the printed design (4).

Table 3: The standard deviation of the three axes of the questionnaire topics according to the specialists' responses

		Design (1)	Design (2)	Design (3)	Design (4)	Design (5)	Design (6)	Design (7)	Design (8)	Design (9)
First Axis	Topic 1	0.74	0.96	0.49	0.51	0.74	0.72	0.64	0.62	0.63
	Topic 2	0.74	0.70	0.46	0.51	0.49	0.46	0.49	0.62	0.51
	Topic 3	0.46	0.74	0.00	0.41	0.56	0.41	0.49	0.35	0.41
	Topic 4	0.49	0.93	0.51	0.49	0.74	0.51	0.49	0.56	0.51
	Topic 5	0.52	0.88	0.51	0.51	0.74	0.49	0.51	0.59	0.64
	Topic 6	0.64	0.88	0.63	0.49	0.74	0.63	0.64	1.06	0.64
	Average	0.60	0.85	0.43	0.49	0.67	0.54	0.54	0.63	0.56
Second Axis	Topic 1	0.46	0.41	0.41	0.91	0.74	0.62	0.96	0.94	0.63
	Topic 2	0.49	0.49	0.26	0.52	0.49	0.56	0.49	0.51	0.41
	Topic 3	0.62	0.52	0.35	0.64	0.74	0.80	0.52	0.64	0.35
	Topic 4	0.41	0.46	0.46	0.64	0.64	0.80	0.70	0.82	0.41
	Average	0.49	0.47	0.37	0.68	0.65	0.69	0.67	0.73	0.45
Third Axis	Topic 1	0.64	0.72	0.35	0.52	0.41	0.35	0.41	0.63	0.62
	Topic 2	0.62	1.06	0.46	0.86	0.59	0.56	0.46	0.52	0.63
	Topic 3	1.05	1.28	0.62	0.88	0.62	0.56	0.49	0.64	0.74
	Topic 4	0.63	1.03	0.35	0.91	0.59	0.35	0.46	0.63	0.74
	Average	0.73	1.02	0.44	0.79	0.55	0.46	0.45	0.61	0.68

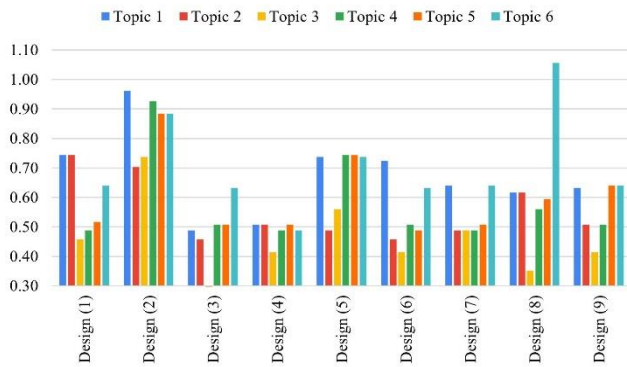


Figure 15: The standard deviation of the first axis topics according to the specialists' responses

Figure 16 shows the standard deviation of specialists' responses on the second evaluation axis concerned with the flat pattern and the fabric. The results indicate agreement on the role of flat patterns of designs (2) and (3) in reducing waste generated in the cutting process. They also agreed that the printed design was not significantly affected by the appearance of the wearing style of the design (3). There was almost agreement on the suitability of

knitted fabrics in designs (3) and (9). Additionally, there was consensus that designs (1) and (9) have successfully reduced costs associated with sewing and finishing.

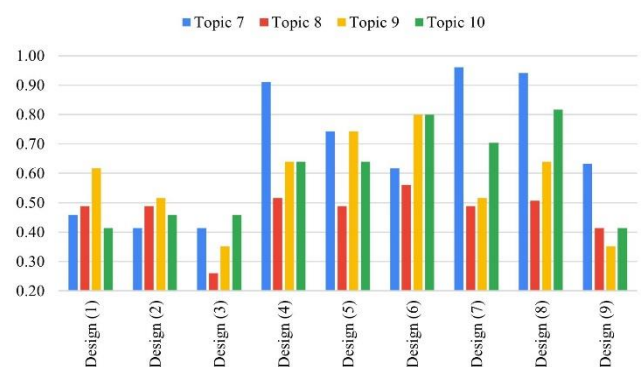


Figure 16: The standard deviation of the second axis topics according to the specialists' responses

The standard deviation for the responses of the third axis of evaluation concerned with the final product is shown in figure 17. There was significant agreement around the suitability of the printed designs to the final products of designs (3) and (6). Also, there was

a consensus that designs (3) and (7) were the most matched contemporary fashion trends. Moreover, the specialists agreed that design (7) was distinctive and innovative. Furthermore, designs (3) and (6) are more marketable than the others.

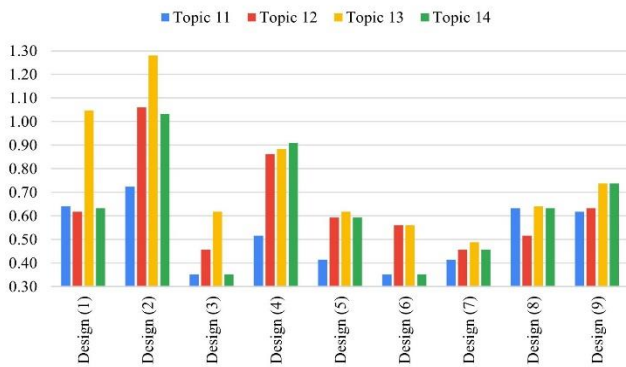


Figure 17: The standard deviation of the third axis topics according to the specialists' responses

The standard deviation average for each design on the three axes of evaluation is represented in figure 18. These collected results indicate the consensus of

opinions about the design (3) in achieving motifs quality, design foundations, the flat pattern, the used fabric, and the final product.

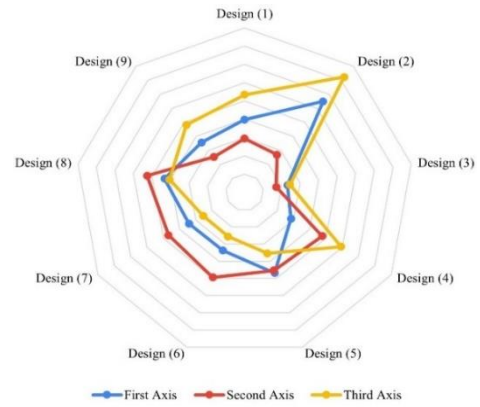


Figure 18: The standard deviations average of designs evaluation on the three axes

The overall evaluation average for the three axes was calculated for the mean, standard deviation, and percentage averages to detect the level and ranking of the proposed designs, as shown in Table 4.

Table 4: Overall evaluation of the designs according to the total axes

	Mean	Standard Deviation	Percentage (%)	Level	Rank
Design (1)	4.57	0.61	91.33	Excellent	6
Design (2)	4.28	0.79	85.62	Excellent	9
Design (3)	4.76	0.42	95.24	Excellent	1
Design (4)	4.46	0.63	89.24	Excellent	8
Design (5)	4.62	0.63	92.48	Excellent	4
Design (6)	4.74	0.56	94.76	Excellent	2
Design (7)	4.58	0.55	91.52	Excellent	5
Design (8)	4.50	0.65	89.90	Excellent	7
Design (9)	4.66	0.56	93.14	Excellent	3

The two radar charts in figure 19 represent the nine designs' overall percentages and standard deviation. Remarkably, design (3) achieved the highest percentages in the evaluation and minor differences in opinions on the three axes. In contrast, design (2)

obtained the lowest percentage in the evaluation, and there were significant differences in opinions about it in the average of total questionnaire topics for the three axes.

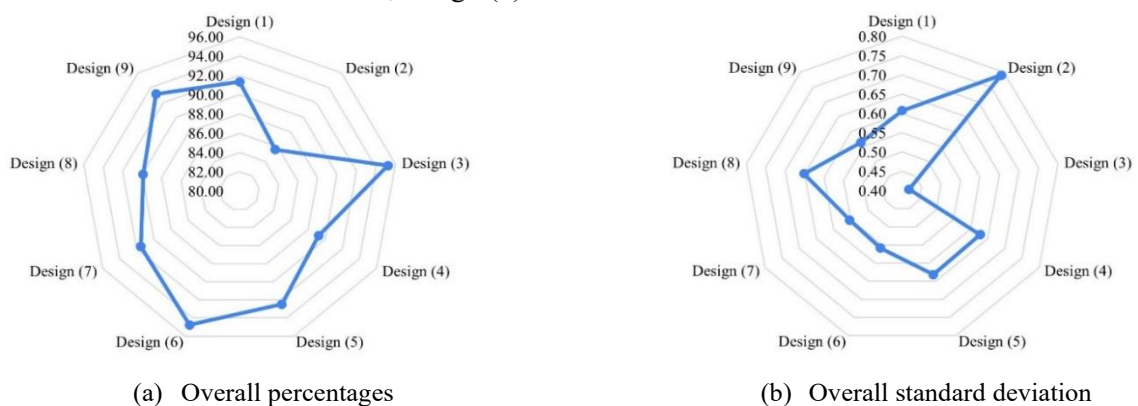


Figure 19: Overall design evaluation by total axes

8. Conclusion

The valuable aim of this work was to achieve sustainability during the processes of producing the beachwear cover-ups starting from the design of the one-piece flat pattern to the final printed product. The one-piece flat pattern was made to benefit from the width of the fabric to minimize fabric wastes due to cutting, considering diversity to obtain different shapes and styles. The printing designs were inspired by crochet motifs of seaside and ocean creatures to merge between handicrafts and digital crafts, add sustainable values, and provide new aesthetic perspectives. The single jersey knitted fabric was ideal for keeping the garment seams free after cutting without tensile deformation. Also, the width of the fabric was convenient for the sizes of the proposed garment designs. The fabric component (80% Polyester – 20% Spandex) helped reach high-quality printing results due to the high ratio of Polyester. Sublimation printing has been utilized because it uses less water, dyes, and chemicals, thereby protecting the environment. The final cover-up products could be worn differently without seams and closures. All these factors worked together to reduce waste and achieve sustainability.

This work combines old ideas with new ones to fit current trends. Even though the variations in the evaluation among the proposed designs, the overall evaluation was at an excellent level, indicating the designs' success in achieving the goal of this work. The proposed nine printed cover-ups were generally accepted for all three evaluation axes. According to the specialists' opinions, the crochet motifs were implemented with excellent quality, and the printed design successfully incorporated all the design elements and principles. The flat pattern makes maximum use of the fabric and thus helps reduce fabric waste even further. The knitted fabric helps in keeping the edges clean after cutting without sewing. Finally, all final products match contemporary fashion trends, achieve distinction and innovation, and are valid as marketable products.

9. Acknowledgments

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10. Ethical Approval

This study was approved by the research ethics committee of the Faculty of Women for Arts, Science, and Education – Ain Shams University (Register Study Code # ASU/W/Sci-7R/23-1-10).

11. References

- [1] Abou Hashish, H. Z., 2017. Handicrafts role in the development of the contemporary creative economy. *Journal of Specific Education and Technology (Scientific and Applied Researches)*, December, Volume 1, pp. 838-879.
- [2] Abou Hashish, H. Z. & El Zean, C. M., 2022. Innovative Printed Scarf Designs Utilizing Crochet Motifs. *International Design Journal*, 12(2), pp. 185-195.
- [3] Almond, K., 2018. Zero Waste Fashion Design. *Fashion Practice*, 10(1), pp. 119-123.
- [4] Amin, R. & Mahmud, A., 2020. Structural Impact on Some Common Physical Properties of Single Jersey Weft Knit Fabric. *AATCC Journal of Research*, 8(4), pp. 36-46.
- [5] Anon., 2022. *Bright*. [Online] Available at: <https://bright-eg.com/cottonish-2/> [Accessed 19 December 2022].
- [6] Bailey, R. & Townsend, K., 2015. Craft and the handmade: Making the intangible visible. *Craft Research*, 6(2), pp. 157-163.
- [7] Bilgiç, H. & Baykal, P. D., 2017. The effects of fabric type, fabric width and model type on the cost of unit raw material in terms of apparel. *IOP Conference Series: Materials Science and Engineering*, 254(17).
- [8] Casciani, D., Chkanikova, O. & Pal, R., 2022. Exploring the nature of digital transformation in the fashion industry: opportunities for supply chains, business models, and sustainability-oriented innovations. *SCIENCE, PRACTICE AND POLICY*, 18(1), pp. 773-795.
- [9] Catalonia, 2022. *How To Choose The Right Beach Cover Ups?*. [Online] Available at: <https://cataloniastore.com/blogs/news/how-to-choose-the-right-beach-cover-ups/>

- [choose-the-right-beach-cover-ups](#)
[Accessed 14 December 2022].
- [10] Çınar, P., 2017. Art as a Source of Inspiration in Fashion Design. *New Trends and Issues Proceedings on Humanities and Social Sciences*, November, 4(11), pp. 53-61.
- [11] Dash, A. K., Nayak, R. & Sahoo, S. K., 2022. Testing and evaluation of knitted fabrics. In: S. Maity, S. Rana, P. Pandit & K. Singha, eds. *Advanced Knitting Technology*. UK: Woodhead Publishing, pp. 623-656.
- [12] Eckman, E., 2008. *Beyond the square crochet motifs: 144 circles, hexagons, triangles, squares, and other unexpected shapes*. s.l.:Storey Publishing.
- [13] Eckman, E., 2012. *Connect the shapes crochet motifs: Creative techniques for joining motifs of all shapes; Includes 101 new motif designs*. s.l.:Storey Publishing.
- [14] Enes, E. & Kipöz, Ş., 2020. The role of fabric usage for minimization of cut-and-sew waste within the apparel production line: Case of a summer dress. *Journal of Cleaner Production*, Volume 248, p. 119221.
- [15] Feyerabend, R., 2004. *Textiles briefing paper*. [Online] Available at: <https://timorissanen.files.wordpress.com/2015/04/textilesbriefingpaper.pdf> [Accessed 13 December 2022].
- [16] Hatta, Y., 2020. *150 Favorite crochet motifs from Tokyo's Kazekobo studio*. Tokyo: Tuttle Publishing.
- [17] Karp, C., 2018. Defining crochet. *Textile History*, 49(2), pp. 208-223.
- [18] Lei, G. & Li, X., 2021. A Pattern Making Approach to Improving Zero-Waste Fashion Design. *Fashion Practice*, 13(3), pp. 443-463.
- [19] Mather, R. R., 2015. Chapter 6 - Synthetic Textile Fibres: Polyolefin, Elastomeric and Acrylic Fibres. In: R. Sinclair, ed. *Textiles and Fashion*. s.l.:Woodhead Publishing Series in Textiles, pp. 115-138.
- [20] McKinney, E. et al., 2020. Analysis of Zero Waste Patternmaking Approaches for Application to Apparel. *Sustainability in the Textile and Apparel Industries*, pp. 31-51.
- [21] McMahon, M., 2022. *What is a Cover-Up?*. [Online] Available at: <https://www.wise-geek.com/what-is-a-cover-up.htm> [Accessed 14 December 2022].
- [22] McQuillan, H., 2019. *Zero Waste Design Thinking*. Licentiate dissertation ed. s.l.:UNIVERSITY OF BORÅS.
- [23] Meredith, R., 2004. *Elastomeric Fibres*. England: Woodhead Publishing Limited.
- [24] Meyer, G., 2020. Ocean inspired mathematical art. *Journal of Mathematics and the Arts*, 14(1-2), pp. 108-110.
- [25] Miller, E., 2022. *The 10 Best Beach Wraps, Sarongs & Cover-ups [2022]*. [Online] Available at: <https://upgradedpoints.com/travel/best-beach-wraps/> [Accessed 4 December 2022].
- [26] Naznin, K. N., Tabraz, M. & Sultana, S., 2017. Process & Effective Methods of Pattern Making For the RMG (Readymade-Garment) Sector. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, 7(3), pp. 46-48.
- [27] Nimkulrat, N., 2020. Translational craft: Handmade and gestural knowledge in analogue-digital material practice. *Craft Research*, September, 11(2), pp. 237-260.
- [28] Nimkulrat, N., Kane, F. & Walton, K., 2016. *Crafting textiles in the digital age*. 1st ed. New York: Bloomsbury Publishing.
- [29] Orzada, B. T., 2017. Upcycle and Zero Waste Ensemble. *International Textile and Apparel Association Annual Conference Proceedings*, 74(1).
- [30] Özkan, E. T. & Kaplangiray, B. M., 2019. Investigating thermophysiological comfort properties of polyester knitted fabrics. *Journal of Textile Engineering & Fashion Technology*, 5(1), pp. 50-56.

- [31] Özomay, M. & Özomay, Z., 2021. The effect of temperature and time variables on printing quality in sublimation transfer printing on nylon and polyester fabric. *European Journal of Science and Technology*, April, Issue 23, pp. 882-891.
- [32] Raja, A., Arputharaj, A., Saxena, S. & Patil, P. G., 2019. Water requirement and sustainability of textile processing industries. In: S. S. Muthu, ed. *Water in Textiles and Fashion: Consumption, Footprint, and Life Cycle Assessment*. India: Woodhead Publishing, pp. 155-173.
- [33] Rodriguez, V., 2022. *WHY BEACH COVER-UPS ARE A BEACH ESSENTIAL*. [Online] Available at: <https://stylishlyme.com/travel-clothes/beach-cover-ups/> [Accessed 4 December 2022].
- [34] Roosth, S., 2013. Biobricks and crocheted coral: dispatches from the life sciences in the age of fabrication. *Science in Context*, 26(1), pp. 153-171.
- [35] Rosner, D., Rocchetti, M. & Marfia, G., 2014. The digitization of cultural practices. *Communications of the ACM*, 57(6), pp. 82-87.
- [36] Sarkodie, B., Tawiah, B., Agbo, C. & Wizi, J., 2017. Status and development of transfer printing in textiles—A review. *AATCC Journal of Research*, 5(2), pp. 1-18.
- [37] Sehdev, M. S., 2020. The time of crochet: Interruption, plasticity, and the domestic in Delhi. *Feminist Anthropology*, 1(2), pp. 136-148.
- [38] Suyambulingam, I., S., R., Divya, D. & Rajeshkumar, G., 2022. Novel plant, their composites and applications. In: S. M. Rangappa, et al. eds. *Plant Fibers, their Composites, and Applications*. India: The textile institute book series, pp. 437-456.
- [39] Townsend, K. & Mills, F., 2013. Mastering zero: how the pursuit of less waste leads to more creative pattern cutting. *International Journal of Fashion Design, Technology and Education*, 6(2), pp. 104-111.
- [40] Wertheim, M. & Wertheim, C., 2015. *Crochet coral reef*. Los Angeles: CA: Institute For Figuring.
- [41] Yalcin-Enis, I., Kucukali-Ozturk, M. & Sezgin, H., 2019. Risks and Management of Textile Waste. In: E. Lichtfouse, J. Schwarzbauer & D. Robert, eds. *Nanoscience and Biotechnology for Environmental Applications*. Switzerland: Springer, pp. 29-53.
- [42] Zabulis, X. et al., 2020. Representation and Preservation of Heritage Crafts. *Sustainability*, 12(4), p. 1461.