Aesthetics of Smocking Stitches in Zero-Waste Innovative Fashion Design

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Abstract:
Zero-waste fashion design offers ways to eliminate the textile waste that occurs in garment production. As a design method within a larger philosophy of zero-waste fashion, a fashion system that creates no waste, it provides new perspectives for fashion design practice in the context of sustainability. Zero-waste fashion design challenges traditional ways of designing while facilitating innovative ways to design and fresh aesthetics to emerge. The terms "zero-waste fashion design" or "fashion design without fabric waste" may seem to imply that fabric waste as a criterion is more significant than appearance, fit or cost. However, in designing and making a zero-waste garment, one needs to balance the concern about fabric wastage with concerns about garment appearance, fit and cost. Most of the challenges encountered in this research arose from trying to achieve this balance. During designing, the most challenging issue relating to fit arose from garments described as "square-cut". So, smocking is used to control fullness of the fabric, such as around the yokes, sleeves and waists. Plus smoking can also be incorporated into the garment as an insert by creating gathers and enhances elasticity in garments. The present research aims to create fashion designs without fabric waste by using smocking stitches to enhance the appearance and achieve new aesthetic perspectives.

Keywords:
Zero-Waste
Smocking
Innovative Fashion
Fashion Design

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Introduction
Fashion designers often regard fabric as their raw material but fabric really is a finished product in its own right [(1)]. For the garment manufacturer, a garment costs money to make and this cost is a sum of several parts. Generally the two most significant sources of garment cost are fabric and labour for construction (usually sewing). Fabric makes up approximately 50 percent of the cost price of a garment and labour 20 percent [(2)]. One of the biggest issues associated with the production phase is the creation of unnecessary fabric waste. In the 'cut, make and trim' (CMT) process, up to 15 percent of the fabric is wasted through uncreative approaches to pattern-making. Conventional pattern-making methods produce paper pattern pieces that are often difficult to lay efficiently within the full width and length of the fabric, which then leads to the creation of textile waste during manufacture. Even with the use of computer aided design (CAD) pattern-cutting software programs, which produce a marker using the pattern pieces in an efficient and cost-effective way, waste is unavoidable. [(3)]

When a fashion designer is sketching a garment, the shapes of pattern pieces and how they may interact on a fabric width are not considerations in conventional fashion design. It seems that the primary aim of conventional pattern cutting is to assist in realizing a sketched idea in three-dimensional form; most pattern cutting manuals reinforce this view [(2)]. Although fabric waste is created at various stages of garment life cycle, it is possible to minimize and "design out" fabric waste during the pattern-making and toiling phase by engaging in zero-waste techniques. To do this, the designer/pattern-maker needs to be able to move confidently between the three-dimensional form and two-dimensional pattern-making, going back and forth until, through design choices, fabric waste is minimized. [(3)]

Designers Timo Rissanen and Holly McQuillan have been at the forefront of conceiving alternative formats of clothing configuration and construction in which the layout and shape of pattern pieces is altered to reduce to zero any waste from the layout and cutting process. The result is pieces with repositioned seams, exaggerated lines and a changed aesthetic; and a visible challenge to the unseen inefficiencies that occur at multiple points through the supply chain. [(4)]

A zero-waste garment in this research refers to a garment that has been designed and pattern cut in such a way that when the fabric is cut, all of the fabric is in the garment, and none is left behind as off-cut waste, by using square and rectangular cuts. To fit the fabric on the mannequin, smocking stitches were used to control fullness, enhance the appearance and add aesthetics to designs.

Smocking is a kind of craftsmanship that holding gathers in place by variety of stitched patterns. It is traditionally used to decorate the English folk costume, smock, and represent status of wearer. It is multi- functional that could be used to control fullness of the garment and as a decorative embellishment as well. Smocking starts getting rid of the shadow of craftsmanship and developing in a more modern way that also widely used in art pieces by textiles artist as well. Smocking is commonly found in haute couture collection such as Valentino, Yiqing Yin and Junya Watanabe. Also, today's smocking has fewer boundaries on geometric pattern and works are more focus on freedom expression. [(5)]

Problem statement

The main research question was as follows: "Is it possible to create fashion design without fabric waste by using smocking stitches?" The sub-research questions were outlined below.

- Is using square and rectangular cuts of fabric suitable for achieving zero-waste concept?
- Is smocking technique suitable to control fullness of fabric and achieve appropriate fit on mannequin?
- Do smocking technique success in adding aesthetics perspective of designs?

Aims and Objectives

The research aims to:

- Create fashion designs without fabric waste by using square and rectangular fabric cuts.
- Zero waste concept and smocking technique work well together.
- Smocking stitches control fullness of fabric and add aesthetics perspectives to designs.

1.1. Zero-waste fashion design

The concept of zero waste design includes many different approaches which all aim to eliminate fabric waste. Although its name is new, the idea is much older: for example the traditional Japanese kimonos or Indian saris both make use of one complete piece of a fabric without wasting any of it [(6).] This was originally done for economic reasons since cloth was expensive. However, as fashion began to fit more closely to the body, shaped pattern pieces were required. With a combination of straight and curved lines, pattern now no longer lock together efficiently. This results in the creation of positive and negative space in the cloth, and it is the negative pieces, or scraps, that become the discarded waste. [(3)]

One of the most visible moments of waste production occurs in the cutting room, as the pattern blocks are laid out and the cut loss- the negative space around the pattern pieces- is discarded. Between 10 and 20 percent of fabric can become waste at this stage depending on final layout efficiency. While this may seem minimal, these scraps are more than just a tangible sign of a less-than-perfect pattern cutting method, for they reflect an approach and mindset that accepts such losses as an inevitable and acceptable part of the supply chain [(4)]. Creative pattern cutting is a skill and process through which expert practitioners can translate the constantly evolving fabrics and silhouettes of fashion. While specific pattern cutting skills and methodologies can be learnt, it is acknowledged that the discipline of pattern cutting almost defies mastery, as it shifts and expands to inform and facilitate new garment shaping strategies. Zero-waste, recycling, up cycling and working with advanced materials present pattern cutters with new challenges through which to develop more creative practice; a critical component of contemporary fashion design. [(7)]

To avoid fabric waste, Rissanen suggested a zero waste design approach to patternmaking. It is a process that integrates sketching and patternmaking, and requires the consideration of technical and visual elements of design together [(6)]. The opportunities working within the boundaries of zero waste are for the possible emergence of new forms, a difficulty in copying existing aesthetics and a required holistic approach to design that requires that the designer/pattern maker acknowledge the materiality of the cloth used and develop all aspects of the garment design and production simultaneously [(8)].

There are several ways to approach the aim of zero-waste fashion design through pattern making. The zero-waste pattern making process is initially guided by the size of the fabric and the type of garment one is planning to make. It can be further directed using a fixed area, e.g. using garment blocks to ensure a certain garment form. Geometric shapes such as squares and triangles are accessible pattern pieces because they can

interlock like a puzzle, [9] Fig.1, 2 & 3.

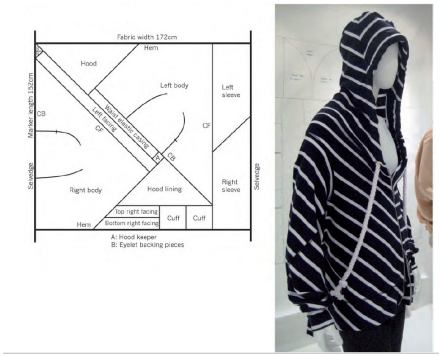


Fig. 1 Timo *Rissanen worked with the geometric shapes to create a zero-waste pattern.* [2]

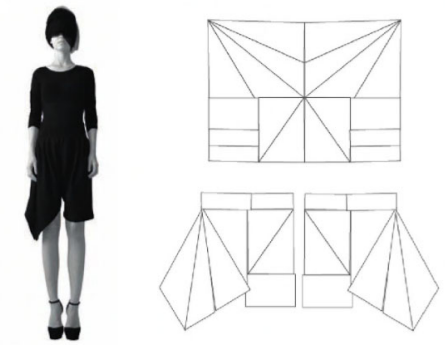


Fig. 2 Pattern Puzzles/ Zero waste. Designed by David Anderesen. [10]

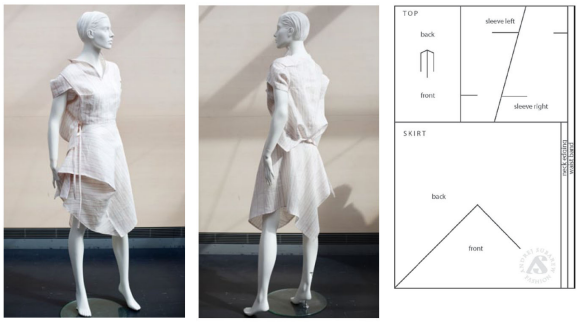


Fig.3 A shirt and a top were designed from one piece of fabric.
Design by Andrej Subarew. [9]

2.2. Smocking technique

Smocking technique is a fabric manipulation technique involving stitching from the back side of the fabric offering a unique and personal aesthetic charm of a hand work. Smocking is one of the oldest handicraft used as a tool by man to express his interest, sentiments and emotions consisting of making tiny, regularly spaced, decorative stitches to create round gathers and tucks on garments. [11]

It is believed that the structure of smocking would be more irregular and complicated with random stitches and combination of different techniques. It is believed that mix and match could help brainstorming ideas and inspiration, explore in new dimension by combining unrelated materials and technique together. This combining technique also works on smocking. It would complement and enhance the richness texture of each other. [5]

2.2.1 American smocking

It is worked entirely on the reverse of the fabric and creates a dense puckered design on the front of the fabric. Traditionally the design is marked out as a series of dots, but a grid is much more effective. Almost any weight of fabric can be used, but fine fabrics may collapse too easily. Thick fabrics should be stitched using a large, widely-spaced grid, while finer fabrics can be smocked on a smaller grid pattern (5mm/1⁄4in).

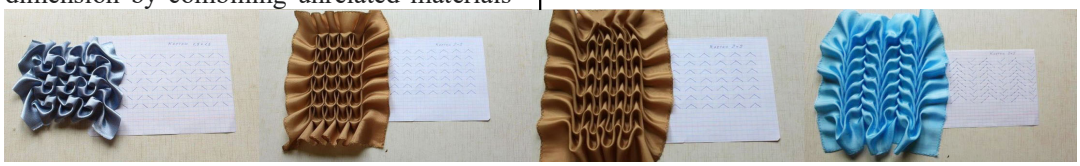


Fig.4 American Smocking technique

2.2.2 English smocking

Traditional English smocking, as seen in farming smocks, is created with a series of fine gathers over which embroidery stitches are worked, before the preparatory gathering stitches are removed. There are many different stitches that can be used for English Smocking such as cable, herringbone and trellis, but the basic preparatory technique is the same. [12]

Fig.5 English Smocking techniqu

3. Materials and methods

Various types of natural/synthetic fabrics (cotton-silk-polyester-poly acrylic) were used to implement fifteen designs. The fabrics vary in thickness between thin, medium and thick. The diversity of fabrics gives the researcher opportunities to experiment and produce new aesthetic perspectives.

In order to accomplish the research objectives, the research designs were based on the concept of zero-waste pattern cutting, which was initially guided by the size of the fabric and the type of design. A zero-waste garment in this research refers to a garment that has been designed and pattern cut in such a way that when the garment is cut, all of the fabric is in the garment, and none is left behind as off-cut waste. The fabrics were cut in fixed shapes (square-rectangle). The shapes dimensions (width-length) were determined according to the mannequin size (small). The inner lines of the pattern depended on straight and curved lines.

Smocking techniques (American/English) were used to modify the three dimensional shape and control fullness of fabric in certain places according to the design. It is a tool to drape and fit fabrics on mannequin. Broader smocking stitches were used in different dimensions to experiment and achieve successful tactile effects that were appreciated from an aesthetic perspective and offered good potential for designs appearance.

The smocking stitches patterns were transferred directly to the reverse of the fabric using marking method (vanishing pen or tailor's chalk) in certain places according to the pattern of the design and the size of the mannequin.

To evaluate the implement designs and be sure that the research objectives were achieved, the researcher designed and constructed a questionnaire includes 10 items as follows:

1- Square/rectangular fabric cuts succeeded in creating the design without any wastage.
2- The design balanced the criteria of garment appearance, fit and cost.
3- Relationship between design and body ensured appropriate fit.
4- Design pattern formed a zero-waste cutting layout on a fabric dimensions.
5- Zero-waste concept and smocking technique worked well together.
6- Smocking stitch succeeded in controlling the fullness of the fabric.
7- The fabric type is suitable to the smocking stitch.
8- Smocking stitch added aesthetic perspectives to the design.
9- Smocking pattern is suitable to the design lines.
10- Design appearance is visually pleasing.

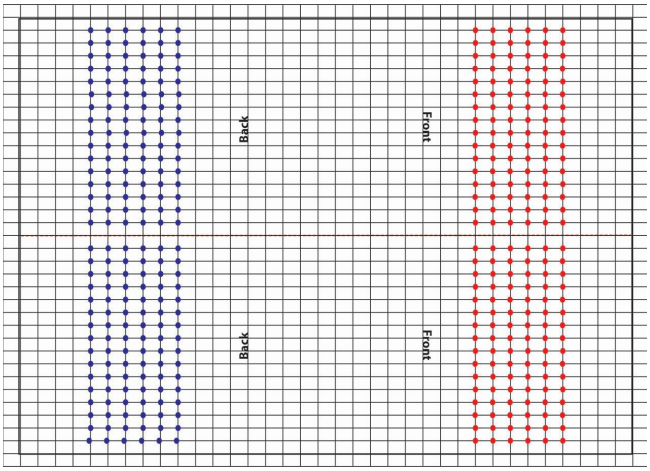
Each item was assessed on a 5-degree (5= strongly agree, 1= strongly disagree).

The designs were subjected to evaluate by fifteen professors and assistant professors in the field of fashion design and apparel production technology, each referee viewed the designs and was instructed to read the items of the questionnaire and place a degree for each item through a personal interview.

3. Results and Discussion

3.1. Presentation of the designs

Each design was presented in an appropriate layout, which consist of the design pattern and the design in front/back positions. Adobe illustrator cs6 was used in drawing the design pattern which included the smocking stitch pattern, as follows

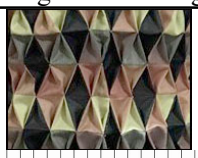


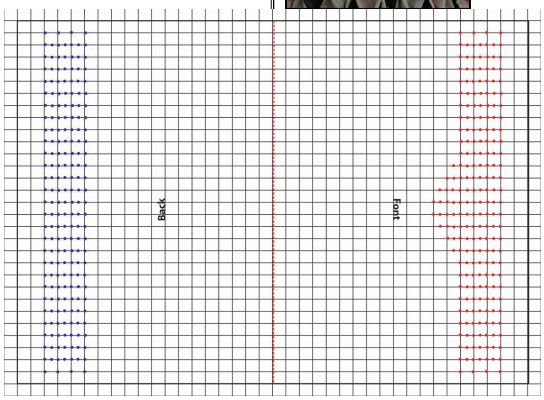
Pattern 1

Design 1 (Front)

Design 1 (Back)

Design 1

Fabric type	Polyester-checked
Pattern dimensions (width/length)	102*123 cm
Smocking technique	English smocking
Smocking stitch sample	



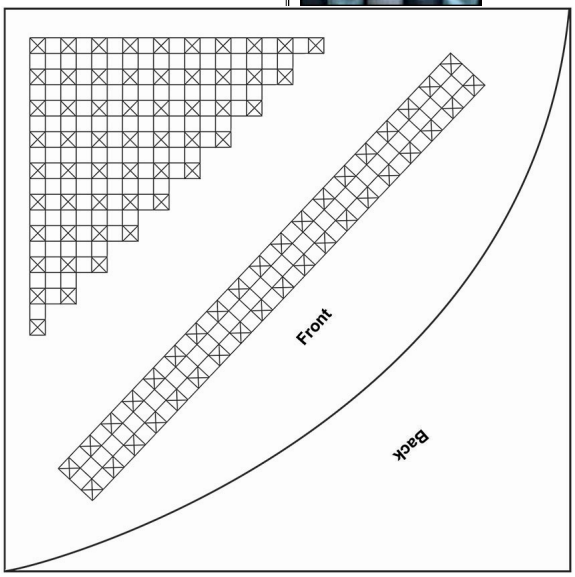
Pattern 2

Design 2 (Front)

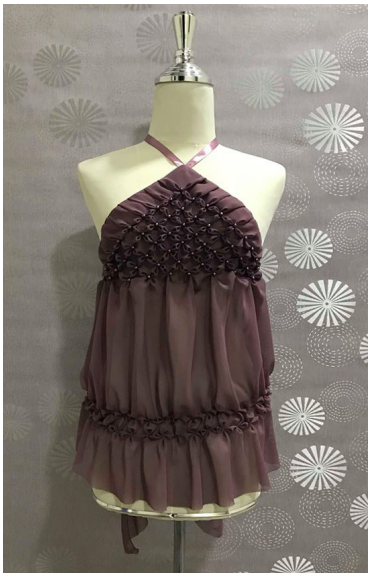
Design 2 (Back)

Design 2

Fabric type	Polyester-checked
Pattern dimensions (width/length)	90*133 cm
Smocking technique	English smocking
Smocking stitch sample	



Pattern 3

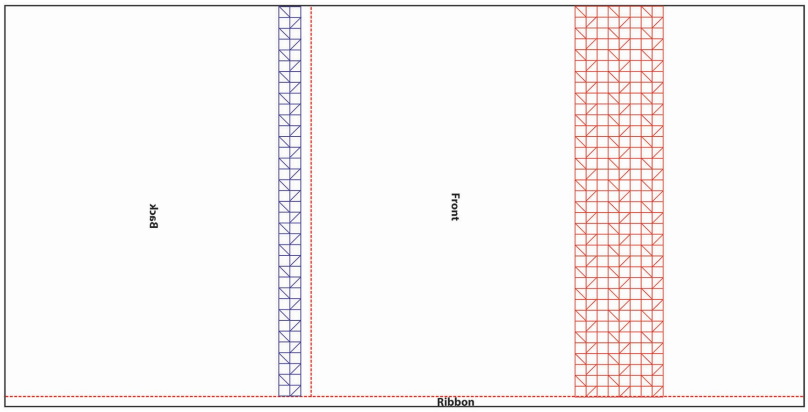


Design 3 (Front)

Design 3 (Back)

Design 3

Fabric type	Polyester/chiffon- plain
Pattern dimensions (width/length)	100*100 cm
Smocking technique	American smocking- double face
Smocking stitch sample	



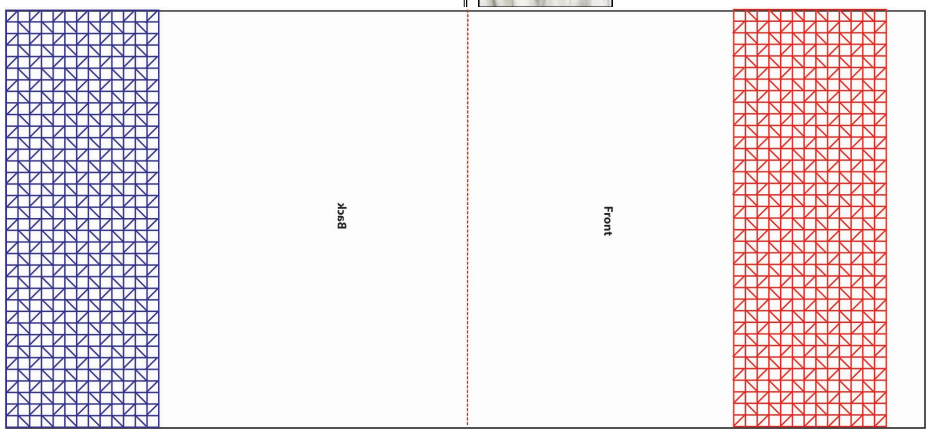
Pattern 4

Design 4 (Front)

Design 4 (Back)

Design 4

Fabric type	Silk/Satin- plain
Pattern dimensions (width/length)	75*145cm
Smocking technique	American smocking
Smocking stitch sample	

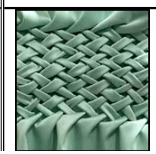


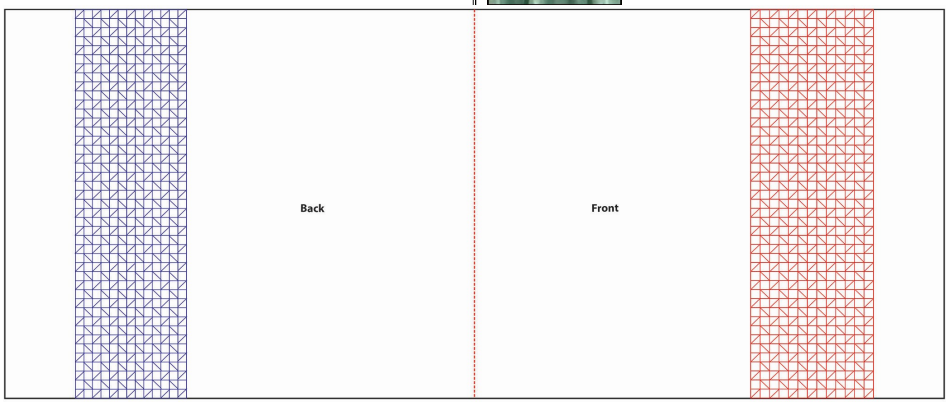
Pattern 5


Design 5 (Front)


Design 5 (Back)

Design 5

Fabric type	Polyester/Taffeta- plain
Pattern dimensions (width/length)	75*160cm
Smocking technique	American smocking
Smocking stitch sample	

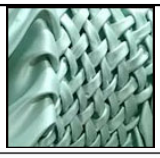


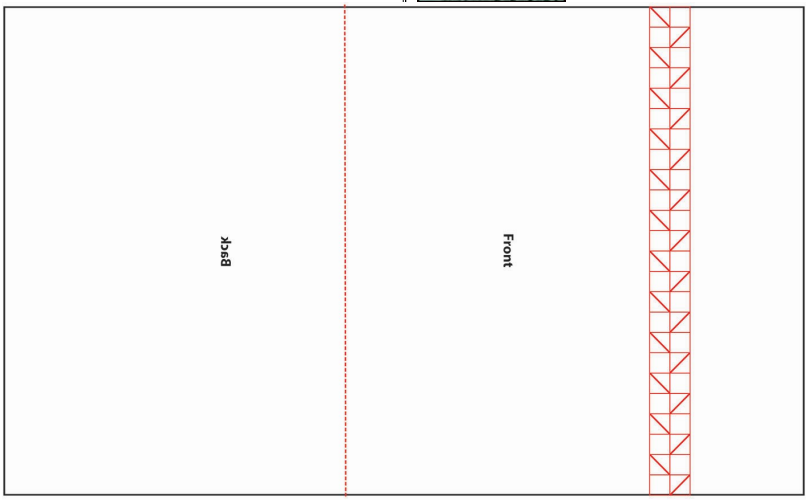
Pattern 6


Design 6 (Front)


Design 6 (Back)

Design 6

Fabric type	Polyester/Taffeta- plain
Pattern dimensions (width/length)	90*200cm
Smocking technique	American smocking
Smocking stitch sample	



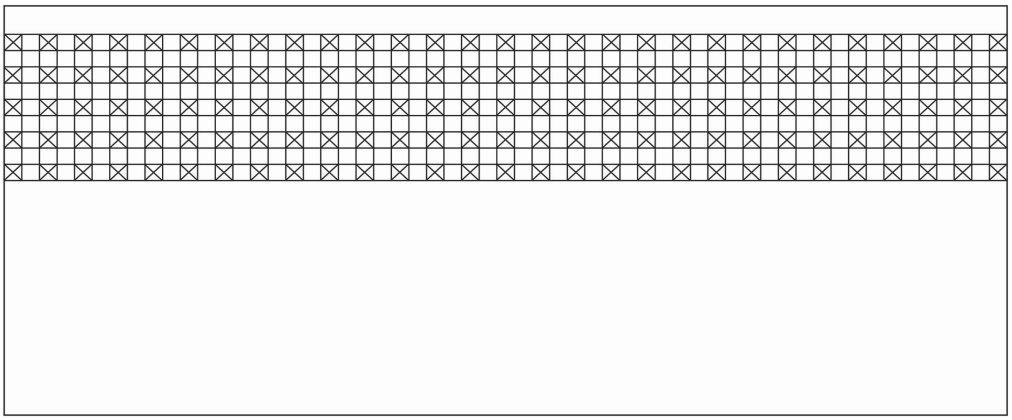
Pattern 7

Design 7 (Front)

Design 7 (Back)

Design 7

Fabric type	Polyester/Taffeta- plain
Pattern dimensions (width/length)	105*170cm
Smocking technique	American smocking
Smocking stitch sample	

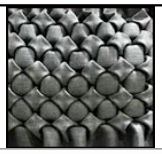


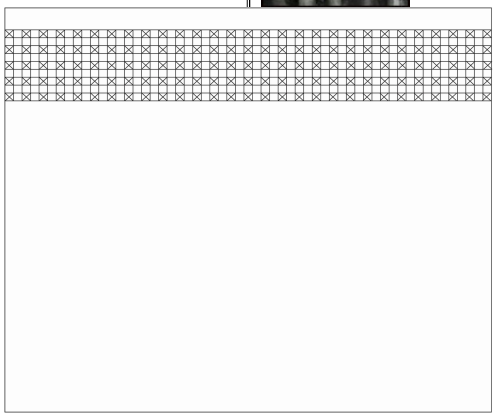
Pattern 8

Design 8 (Front)

Design 8 (Back)

Design 8

Fabric type	Polyester- plain
Pattern dimensions (width/length)	240*100cm
Smocking technique	American smocking- double face
Smocking stitch sample	



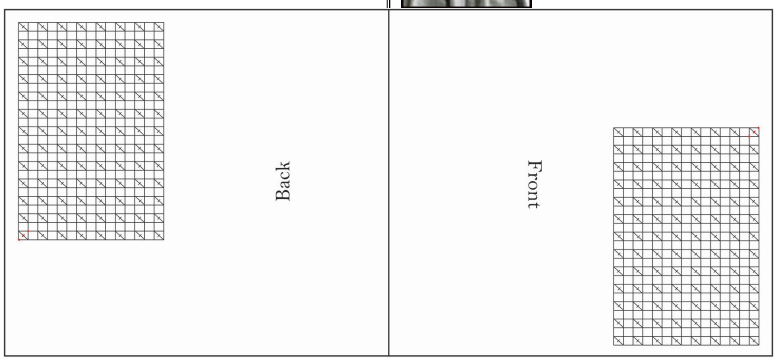
Pattern 9


Design 9 (Front)


Design 9 (Back)

Design 9

Fabric type	Polyester- plain
Pattern dimensions (width/length)	200*240cm
Smocking technique	American smocking- double face
Smocking stitch sample	

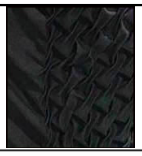


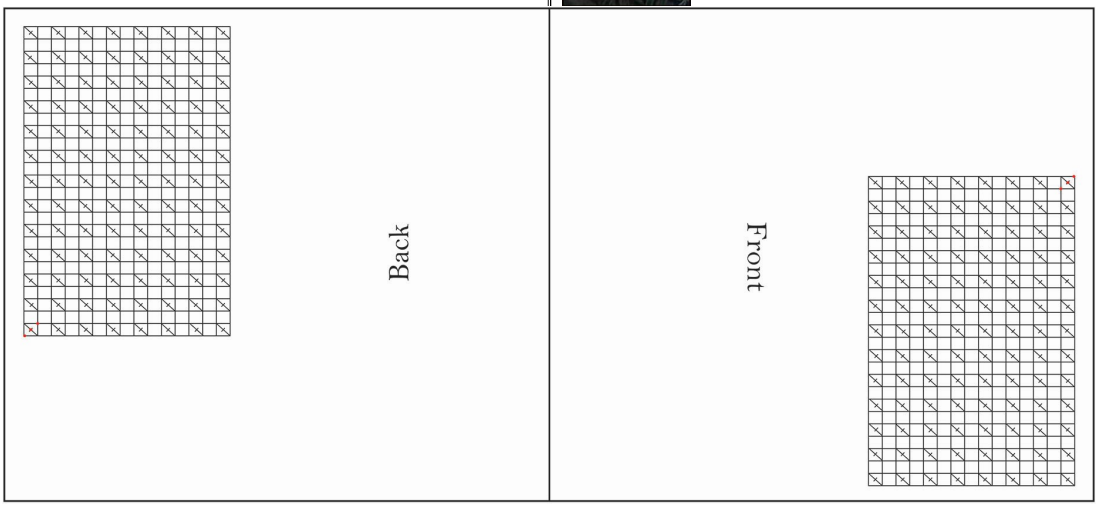
Pattern 10


Design 10 (Front)


Design 10 (Back)

Design 10

Fabric type	Cotton Denim- plain
Pattern dimensions (width/length)	105*200cm
Smocking technique	American smocking
Smocking stitch sample	



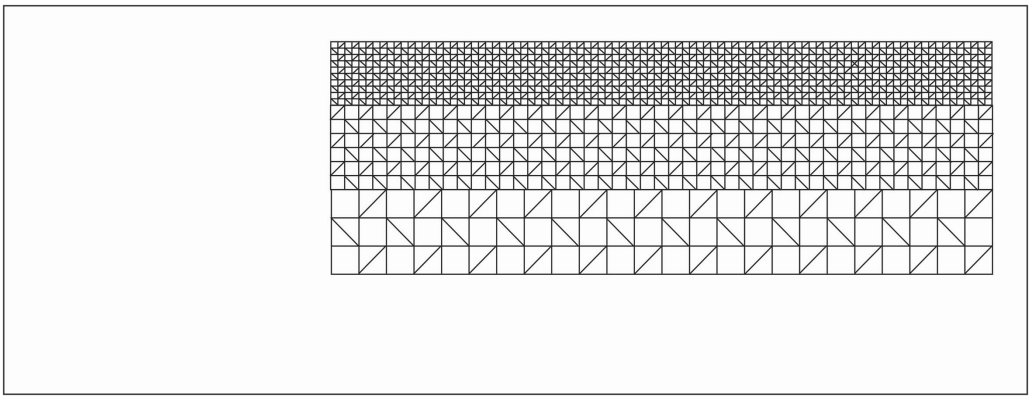
Pattern 11

Design 11 (Front)

Design 11 (Back)

Design 11

Fabric type	Cotton Denim- plain
Pattern dimensions (width/length)	105*200cm
Smocking technique	American smocking
Smocking stitch sample	



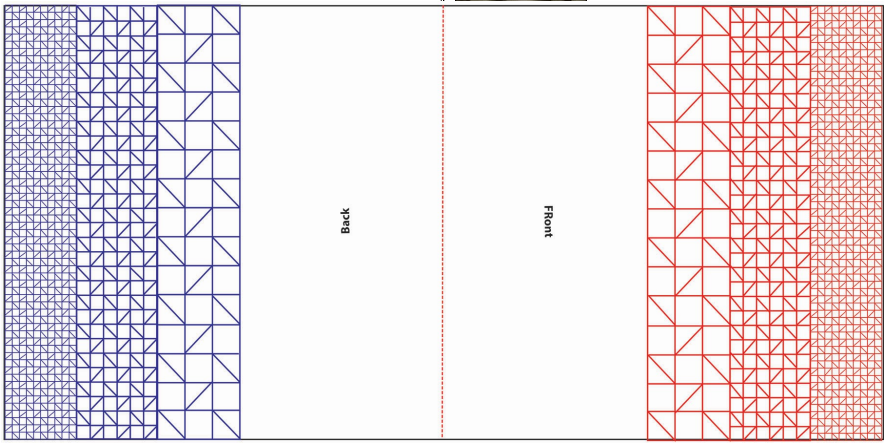
Pattern 12

Design 12 (Front)

Design 12 (Back)

Design 12

Fabric type	Polyester/Chamois- plain
Pattern dimensions (width/length)	170*65cm
Smocking technique	American smocking
Smocking stitch sample	

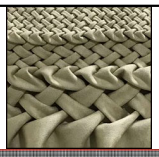


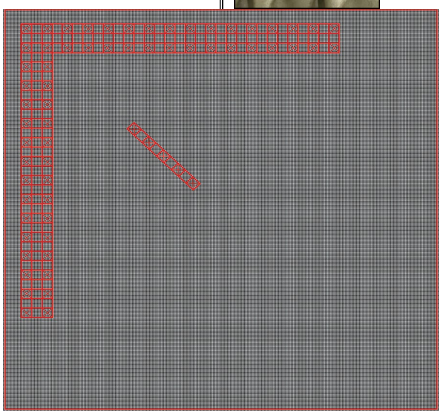
Pattern 13

Design 13 (Front)

Design 13 (Back)

Design 13

Fabric type	Polyester/Chamois- plain
Pattern dimensions (width/length)	65*115cm
Smocking technique	American smocking
Smocking stitch sample	



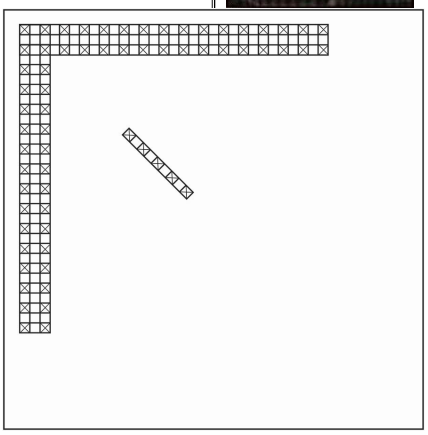
Pattern 14

Design 14 (Front)

Design 14 (Back)

Design 14

Fabric type	Poly acrylic- checked
Pattern dimensions (width/length)	120*120cm
Smocking technique	American smocking- double face
Smocking stitch sample	



Pattern 15

Design 15 (Front)

Design 15 (Back)

Design 15

Fabric type	Poly acrylic- plain
Pattern dimensions (width/length)	120*120cm
Smocking technique	American smocking-double face
Smocking stitch sample	

3.2 Data Preparation and Data Analysis

The data was analyzed using the Statistical Package for the Social Sciences (IBM SPSS Statistics 25). To ensure validity and consistency of the results, the data was screened and leaned at a holistic level incorporating the entire data set.

3.2.1 Reliability and validity

To assess internal consistency for the 5-factor, 10-item model, the Cronbach α score was calculated using the whole sample, construct validity was assessed by computing scale scores for each item by calculating the mean score of the items for each respondent. Inter correlations between the scale scores for the 10-item and the 'overall grade' were

computed to determine the discriminate validity. Strengths were defined artificially as those positively worded items which ≥75% of respondents endorse by answering 'agree/strongly agree', or 'most of the time /always' (or when ≥75% of respondents disagreed with negatively worded items). Areas with the potential for improvement were identified as items which ≤50% of respondents answered positively. The average positive percentage of each dimension and item with 95% confidence interval was calculated

3.2.1.1 Reliability Test

The Cronbach_s a reliability coefficients for the 10 questions were = 0. 819, The Cronbach α score indicated an acceptable level of internal consistency (>0.70)). Cronbach's alpha score was good provide the following rules of thumb regarding levels of internal consistency: >0.9, excellent; >0.8, good; >0.7, acceptable; >0.6, questionable; >0.5, poor and <0.5, unacceptable.

Table 1 displayed the inter-correlations of the 10 questions, and the total scale is significantly different

Table 1 Correlation with the total scale and inter-correlations of the 10 questions

No	Items	Pearson Correlation	Sig
1	Square/rectangular fabric cuts succeeded in creating the design without any wastage.	.780**	0.000
2	The design balanced the criteria of garment appearance, fit and cost.	.826**	0.000
3	Relationship between design and body ensured appropriate fit.	.842**	0.000
4	Design pattern formed a zero-waste cutting layout on a fabric dimensions.	.804**	0.000
5	Zero-waste concept and smocking technique worked well together.	.713**	0.000
6	Smocking stitch succeeded in controlling the fullness of the fabric.	.796**	0.000
7	The fabric type is suitable to the smocking stitch.	.868**	0.000
8	Smocking stitch added aesthetic perspectives to the design.	.777**	0.000
9	Smocking pattern is suitable to the design lines.	.824**	0.000
10	Design appearance is visually pleasing.	.865**	0.000

**** Correlation is significant at the 0.01 level (2- tailed)**

In the above table, correlation analysis indicates that positively correlated appears that all the variables show strong positive relationships with one another. A positive correlation coefficient (r-value) indicates a strong or positive relationship among the variables. None of the variables showed a negative/reverse relationship. All variables indicated strong inter-item correlation. The variables with the highest positive r-value (strongest positive relationship) were found.

3.2.2 Analyzing the quantitative data

3.2.2.1 Results of the descriptive statistics

After gathering the data, we have entered them in SPSS (Statistical Package for the Social Sciences) version 25. These entered data have been analyzed by some of SPSS tools.

As the first analysis, the basic features of the data were described with the descriptive statistics to provide simple summaries about respondents.

After the quantitative data collection process had been completed, data analysis began.

3.2.2.2 Descriptive Statistics

This section contains the descriptive statistics and analyses using ANOVA Analysis

The first section of the questionnaire will provide an overview of the respondents' interaction with 15 designs.

Table 2 Means and percentage of mean and responses

Items	strongly disagree	2	3	4	strongly agree	Mean	%
1	0%	0%	0%	0%	100%	5	100%
2	0%	0%	13.33%	40%	46.67%	4.33	86.67%
3	0%	0%	6.67%	40%	53.33%	4.47	89.33%
4	0%	0%	0%	0%	100%	5	100%
5	0%	0%	6.67%	0%	93.33%	4.87	97.33%
6	0%	0%	6.67%	33.33%	60%	4.53	90.67%
7	0%	0%	6.67%	0%	93.33%	4.87	97.33%
8	0%	0%	6.67%	0%	93.33%	4.87	97.33%
9	0%	0%	6.67%	6.67%	86.66%	4.8	96.00%
10	0%	0%	13.33%	6.67%	80%	4.67	93.33%
Overall						4.74	94.8%

As table 2 of 10 Items, were positive with an overall mean score of 4.74 (% of mean = 94.8%). The majority of respondents agreed to with 15 designs

- The First item with the highest level of satisfaction (100 'strongly agree') was 'Square/rectangular fabric cuts succeeded in creating the design without any wastage'. This also had the highest mean score (M = 5 and 100%).
- The second highest rated item (100% 'strongly agree'; M = 5) was 'Design pattern formed a zero-waste cutting layout on a fabric dimensions'. This also had the highest mean score (M = 5 and 100%).
- The third highest rated item (93.33% 'strongly agree'; M = 4.87) was 'Zero-waste concept and smocking technique worked well together'. This also had the highest mean score (M = 4.87and 97.33%).
- The fourth highest rated item (93.33% 'strongly agree'; M = 4.87) was 'The fabric type is suitable to the smocking stitch'. This also had the highest mean score (M = 4.87 and 97.33%).
- The fifth highest rated item (93.33% 'strongly agree'; M = 4.87) was 'Smocking stitch added aesthetic perspectives to the design'. This also had the highest mean score (M = 4.87 and 97.33%).
- The sixth highest rated item (86.66% 'strongly agree'; M = 4.8) was 'Smocking pattern is suitable to the design lines'. This also had the highest mean score (M = 4.8 and 96.00%).
- The seventh highest rated item (80% 'strongly agree'; M = 4.67) was 'Design appearance is visually pleasing'. This also had the highest mean score (M = 4.67 and 93.33%).
- The eighth highest rated item (60% 'strongly agree'; M = 4.53) was 'Smocking stitch succeeded in controlling the fullness of the fabric'. This also had the highest mean score (M = 4.53 and 90.67%).
- The ninth highest rated item (53.33% 'strongly agree'; M = 4.47) was 'Relationship between design and body ensured appropriate fit'. This also had the highest mean score (M = 4.47 and 89.33%).
- The tenth highest rated item (46.67% 'strongly agree'; M = 4.33) was 'The design balanced the criteria of garment appearance, fit and cost'. This also had the highest mean score (M = 4.33 and 86.67%). as show in chart 1.

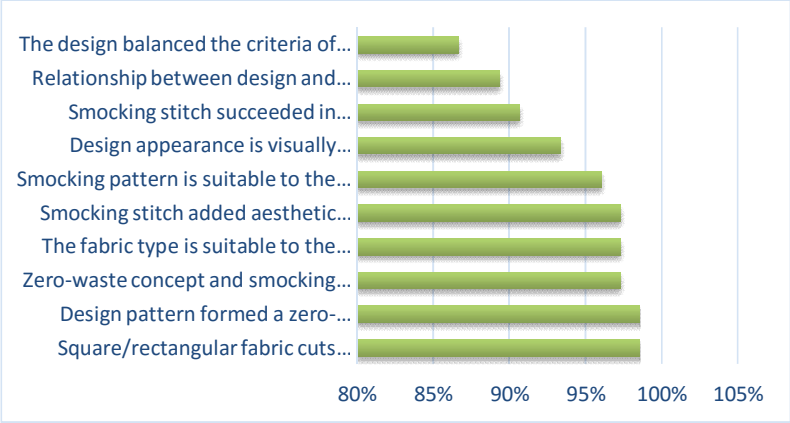


Chart 1 percentage of mean and respondents' interaction with questionnaire items.

Using one-way ANOVA, the F statistic test whether the designs are all equal, that there are differences among the means of the 15 designs. A significant F value indicates that there are differences in the means, but it does not tell us where those differences are, by using LSD TEST we can find which designs are differences

ANOVAs were used to determine if statistically significant differences existed among 15 designs for 15 referees. There were statistically significant differences based on sum of all questions between 15 designs for 15 referees.

Table 3 Analysis of variance (ANOVA)

design	N	Mean	Std. Deviation	rank	F	Sig.
Design 1	15	50.00	0	1	4.966	.000
Design 2	15	49.00	3.162	8		
Design 3	15	50.00	0	2		
Design 4	15	50.00	0	3		

Design 5	15	50.00	0	4
Design 6	15	44.00	4.830	14
Design 7	15	34.00	4.830	15
Design 8	15	48.00	4.216	9
Design 9	15	50.00	0	5
Design 10	15	50.00	0	6
Design 11	15	50.00	0	7
Design 12	15	45.00	5.270	13
Design 13	15	47.00	4.832	10
Design 14	15	47.00	4.832	11
Design 15	15	47.00	4.832	12
Total	225	47.4	2.453	

Table3 shows the descriptive statistics of all design of all referees.

For "Design 1, 3, 4, 5, 9, 10& 11 ", have the highest mean of 50 (=100%). Subsequently, it followed by Design 2 and Design 8. However, Design 7 has the lowest mean which 34.00 (=68%) as show in chart 2.

As shown in Table 3 the ANOVA, Table 3, F= 4.966; p= 0.000

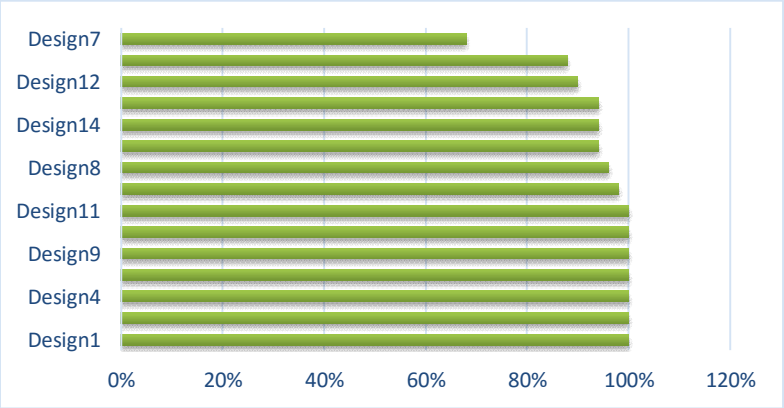


Chart 2 percentage of mean and respondents' interaction with 15 designs

The differences according to referees regarding the reading frequency of and the importance assign to various design. It was found that there is a statistical significance by creating fashion designs without fabric waste by using smocking stitches to enhance the appearance and achieve new aesthetic perspectives.

4. Conclusion

- Zero-waste fashion design can be a tool for eliminating fabric waste, namely off-cuts, and increasing the efficiency of fabric use in garment production. Zero-waste fashion design serves as a compelling example of how to merge the skills of fashion design and pattern making.
- Zero-waste fashion design can also be combined with smocking techniques to add aesthetic perspectives to designs and control fullness of the fabric. Most of all zero-waste fashion design can change fashion designers' attitudes towards more respectful resource use.
- According to the evaluation of designs and the referees' opinions, "Design 1, 3, 4, 5, 9, 10& 11 ", have the highest mean of 50 (=100%). Subsequently, it followed by Design 2 and Design 8. However, Design 7 has the lowest mean which 34.00 (=68%).
- By using Statistical analysis of referees' opinions, it was found that there are differences of statistical significances which confirms that the research aim "creating fashion designs without fabric waste by using smocking stitches to enhance the appearance and achieve new aesthetic perspectives." is achieved.

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