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 التنمية المستدامة للمجتمعات بالوطن العربي
 دور الثقافة والتراث والصناعات الابداعية
 والسياحة والطوم التطبيقية في التنمية المستدامة

Using fabric manipulation as an important aspect of zero waste fashion implementing fashion sustainability

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Introduction

Fashion is the second most polluting industry after the oil industry. While much of material waste comes from consumers, the pre-consumer production chain is a significant contributor. On average, 15% of fabric is discarded on factory floors during cutting, assembly and quality-checking stages. This may sound negligible, but with nearly 400 billion square meters of fabric being produced per year

A culture of excess and wastefulness, that devalues fashion garments without conscious consideration of the raw material, production or design value, is impacting the potential for more sustainable consumer practices. In addition to textile waste, excess exists in manufacturing processes where the cost of labor is devalued and the need to develop designed, streamlined, efficient and ethical manufacturing methods is not as significant to reducing production costs.

The problem of textiles waste is not new to the fashion and textiles industry. The focus of sustainable research throughout the past two decades has identified and explored a wide range of problems arising from unsustainable industry practices that continue to have negative environmental outcomes. The associated social and economic aspects of unsustainable practices are now returning to the foreground of discussions around sustainability. Recent tragedies involving the horrific death of hundreds of factory workers, such as the 2013 Bangladesh factory fires, profile the human face of the problem of unsustainable practices within the global industry. While the environmental issues are real, addressing the social aspects of continuing mass consumerism and mass production is becoming equally imperative. Overproduction and overconsumption have become characteristic of this type of manufacturing model and result in a prematurely shortened product life-cycle.

In other words, fashion contributes to a culture of planned obsolescence and under-use that has led to unsustainable levels of wasted labor, raw materials and wasted design. An advantage of focusing on the design phase of a product life-cycle is that design deals with the problem of textiles waste before it occurs

rather than aiming to provide solutions to a problem that already exists.

This research discusses the beginnings of an interactive design involvement with the aims of facilitating transformative thinking in apparel sustainable design production. Recently there has been a significant move by designers, apparel companies, to make positive changes directly related to issues of environmental and social impact. An increased awareness of sustainable issues has begun to be seen across the apparel sector, including cyclical design thinking, ethical and efficient manufacturing and sourcing of materials, and management of waste.

This research proposes an experiment of waste minimization, throughout the production cycle, as a potential design strategy to generate a stronger commitment between the fashion industry and more sustainable design practices.

Research aim

- Identify that practice-led research has a lot to offer in addressing unsustainable practices within fashion and textiles by engaging with the design of fashion objects in an innovative and practical way
- Creating a new way of thinking about shape when creating a pattern, and using fabric manipulation to explore and develop any possible waste elements so that the potential 'waste' sections become part of the finished garment

Research questions:

- What are the opportunities for creating zero-waste garments within contemporary womenswear fashion design practice using fabric manipulation method?
- To what extent is a zero-waste approach feasible and desirable within contemporary fashion industry?

Strategies for developing more sustainable fashion practices

Zero-waste is a design technique that eliminates textile waste at the design stage. While sustainability can be an outcome of such designing, in fashion, zero-waste design can also be a tremendously creative patternmaking challenge by uniting the roles of designer and patternmaker in a holistic approach to creating garments, considering aesthetics and function simultaneously. Approximately 15 percent of textiles intended for clothing ends up on the cutting room floor. When textiles are wasted so too are the resources, both natural and human labor resources, which were invested and imbedded into the textiles. It is vital to address the source of the problem by maximizing the use of textile materials and by minimizing the wastage. Adopting a zero-waste design approach reduces textile waste and the demand on natural resources.

The vast amount of textiles waste within the fashion industry has resulted in committed research within the emerging field and has been an area of focus for some fashion researchers from many different countries. A review of existing literature and practice surrounding fashion textiles waste reveals that there are three dominant approaches to addressing the problem.

Firstly, strategies such as zero-waste cutting aim to prevent the waste of textiles in the production phase of the garment lifecycle (McQuillan, Rissanen, and Roberts 2013, Rissanen 2013).

Secondly, aiming to extend the original garment life-cycle through the provision of reliable garment services draw on a 'mend and make do' approach (Gwilt 2012, Finn and Fraser 2014).

Finally, interventions that aim to divert textiles from landfill at the end of the garment life-cycle include strategies such as up-cycle, re-make and re-use (Fletcher 2008, Fraser 2009).¹

Amongst the dominant strategies the focus has been to prevent or reduce the number of textiles that ends up in landfill by extending the 'use' phase of the garment life-cycle through the development of various methods of redesign and reuse. However, all these approaches are dealing with the second life phase of the garment object.

Fashion Design Industry Impressions of Current Sustainable Practices

Current practices in the fashion industry and the use of textile materials are unsustainable. The consumption of clothing and textile products has increased simultaneously with an exponential increase in production

Sustainable practices in clothing have not, thus far, created a significant impact and instead continue to be largely marginalized within the fashion industry. The fashion industry continues to work in an inefficient manner that creates massive waste, exploits workers, and makes it increasingly difficult to make a substantial profit. There is wide disagreement among design environmentalists where energies must be focused to solve these problems. Designers are, however, responsible for as much as 80 percent of any product that is introduced and can influence how fabric is sourced and how clothing is produced, cared for, and then discarded.

The increased need to consider sustainability in the field of apparel is gaining awareness among designers, producers, marketers, and consumers who are currently considering their next moves in the arena of apparel products, design, and innovation. The paradox of fast fashion and the pursuit of modernity, alongside the need to care for the earth's resources in a sustainable manner that includes social, economic, and environmental impacts, is a difficult dilemma.

What is Zero-Waste Fashion (and Why Does It Matter)?

Implementing Zero Waste to cloth design means creating a strong garment whilst efficiently utilizing the 100% of the fabric used in production. Indeed, the idea is to design in a way that enables to use every single square millimeter of the fabric. It is the virtue of the designer, to create simple designs, so even the thinnest part of the fabric, will be integrated in the final design, thus eliminating waste.

Zero-waste design isn't a new technology or material. Instead, it's a new way of thinking—a philosophy that forces you to challenge existing techniques and become a smarter designer. Technique-wise, it involves fitting all the flat pieces of your clothing pattern like [a jigsaw puzzle](#) so no fabric is wasted.

Manufacturers have long used computer software to optimize fabric usage and reduce waste, mainly for economical purposes.

There are generally two strategies for zero-waste fashion: creative pattern making that uses 100% of a given material, and generating garments from remnant materials.

Fashion designers implement zero waste fashion techniques:

Many fashion designers and manufacturers around the world are implementing zero-waste production solutions. The key objective for them is to move away from the traditional take-make-dispose model of production to one where, theoretically, waste doesn't exist in the value chain, waste should be as much a consideration for designers as appearance, fit and cost.

- Seamless knitting is an older method where the yarn is directly knit into finished garments. It avoids the need to cut fabric and thus reduces waste generation. This technique is most used for sportswear, knitwear, undergarments and safety gear. Nike's Flyknit technology and Adidas' Adizero Primeknit, both based on seamless knitting, have engineered popular shoes and apparel that have come to be known for their comfort. Seamless knit garments are sold at many leading brands like Lacoste, Gap, Old Navy, Prada, D&G and Burberry.

- Indian fashion designer Siddhartha Upadhyaya puts computers at work for a smart tailoring technique called **Direct Pattern on Loom (DPOL)**. In place of weaving rectangles of fabric that are then cut, DPOL computers weave fabric from the loom to the required pattern shape, thereby eliminating waste creation. His brand, **August**, not only reduces fabric waste by 15%, but also saves on energy, labor, time and chemical usage.

- **David Andersen** is a good example of how zero waste can be built into a production process and at the same time bring added value to the project. David Andersen Design, a successful Copenhagen design label since 2007, has decided to go follow the Zero Waste path."

- **Tonlé** A zero-waste fashion label producing in Cambodia, who uses a mix of two zero-waste approaches; 'using 100% of the given material' as well as 'generating garments from remnant materials'. Their process starts with scrap waste sourced from mass clothing manufacturers.



Siddhartha Upadhyaya at Lakme fashion week S/R 2010



Tonlé A/W 2014 designs



David Andersen 2015 Spring Summer Women's Runway

The Eco-Chic Design Award

The Eco-Chic Design Award is a sustainable fashion design competition organized by Redress, inspiring emerging fashion designers and students to create mainstream clothing with minimal textile waste. Each competition cycle takes designers on an education and design journey lasting several theory and design-packed months. This puts sustainable design talent in the spotlight and rewards the best with career-changing prizes to change the pattern of fashion.



Eco-Chic Design Award 2016

What is Fabric Manipulation?

Fabric manipulation is an amazing art that transforms a piece of fabric into a 3-dimensional material. There are many ways to play with fabric and manipulate or control it so that it becomes more dimensional. Throughout history, people have developed different ways of altering fabric to provide contrasts, to create a sense of fullness, and create surface effects. Some of these methods are very old, but contemporary fabric artists continue to use them and adapt them in new ways.

There are several fabric manipulation techniques like:



Gathering



Shirring



Pleating



Tucking



Smocking



Quilting



Appliqué/applied work



Stitching - Hand stitching



Beads and Beading



Patchwork

Fashion designers applied fabric manipulation in their designs:

- Shaun Samson, Central Saint Martins MA, AW10.

Shaun Samson is one menswear designer who is building his collections on techniques such as smocking, used to draw sections of the fabric together, and felting, used to blend together different fibers into one continuous piece.

- Rodarte, AW14, New York.

From a construction perspective, the Rodarte collections tend to revive or reference the sort of techniques expected to see in a dusty craft magazine whether it's patchwork and quilting, or in the case of Autumn-Winter 2014, smocking and crochet. In a way it is the adaptation of these homely, retro construction techniques that helps to give depth to the awkward nostalgia of their collections.

- Chanel, AW15, Paris.

Mixed among the traditional tweeds and bouclés of the Chanel Autumn-Winter 2015 collection were several fabric manipulations that added volume and texture to the garments.

- Threeasfour, SS14, New York.

There were some interesting uses of laser cutting and 3D printing at the Threeasfour show for Spring-Summer 2014 where geometric patterns of laser cut fabric were layered up to create soft effects. At times the large spaces opened in some of the fabrics by the laser cutting techniques changed the handle of the fabric and created lovely drape qualities

- Noir kei ninomiya, AW15, Paris.

It comes as no surprise that someone who used to be a pattern cutter at Comme des Garçons would produce intricately designed garments, however, based on the collection shown for Autumn-Winter 2015, it is also clear that Kei Ninomiya has a flair for ingenious modular patterns and contemporary updates of smocking and macramé.

- Miu Miu, SS12, Paris.

In Spring-Summer 2012 collection for Miu Miu Miuccia Prada has reworked the smocking technique on cotton and satin dresses and capes and even extended the technique into the embellishment on hand bags.



Shaun Samson, Central Saint Martins MA, AW10.



Rodarte, AW14, New York.



Chanel, AW15, Paris.



Threesfour, SS14, New York.



noir kei ninomiya, AW15, Paris.



Miu Miu, SS12, Paris.

Mini collection Designing phase:

In designing a collection aimed to directly engage with developing more sustainable practices, and within the limitations of postgraduate studies that are inherent in all universities, there are processes and concepts that are obvious to practitioners

In terms of developing more sustainable methods that engage with sustainable design, the practice-led outcomes of the collection resulted in the development of a theory of 'design for redesign' that proposes extending both the first life of fashion garments by building in the option for redesigning by minimizing invasive cutting and construction in the first instance.

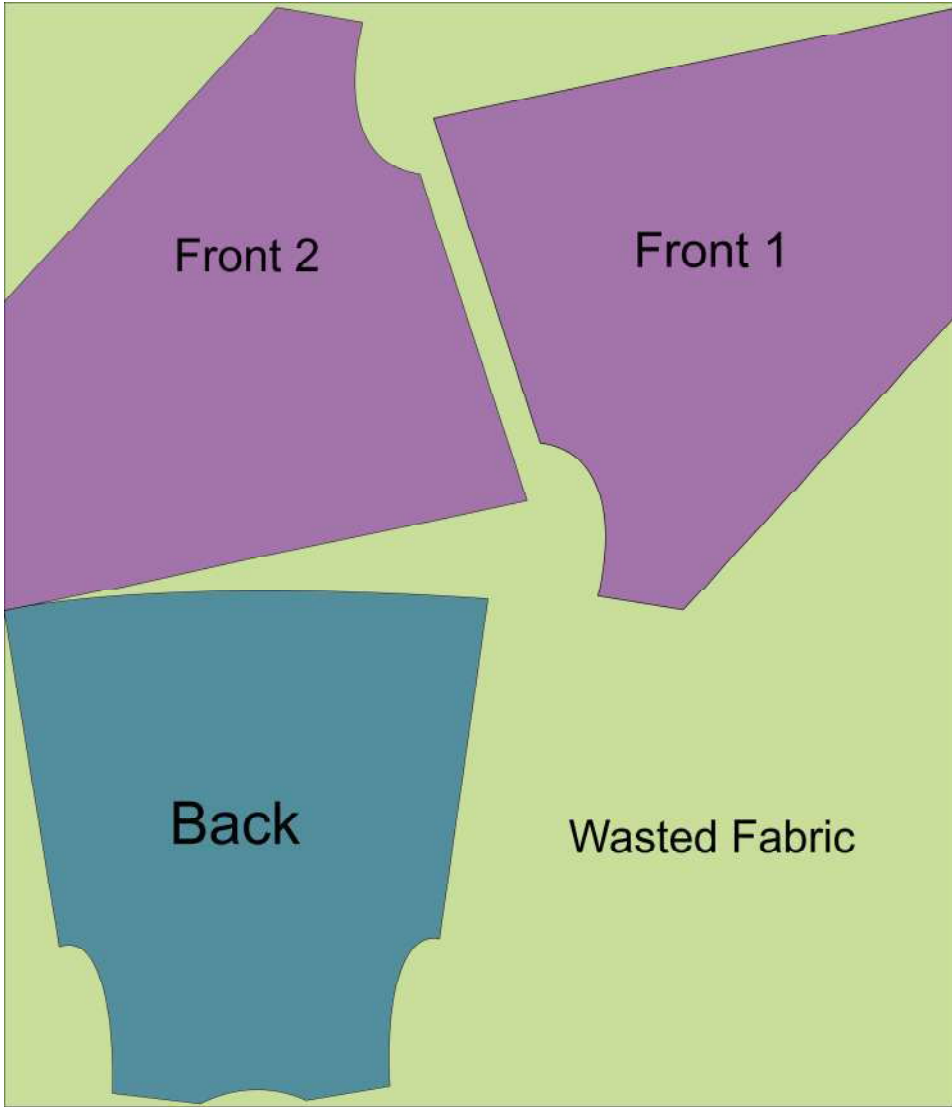
Building this mini collection depends on the idea of simple pattern lines and exploiting every single centimeter of the wasted fabrics by using fabric manipulation techniques and redesign putting in mind adding this new material on the original design

Fabric Manipulation Techniques used in implementing the idea is:

- Design 1: Lotus flower smocking
- Design 2: Gathered double edged ruffles
- Design 3: Fabric Cording
- Design 4: Cross shirring
- Design 5: Doubled controlled pleats with ripple effect
- Design 6: Smocked tucks



Pattern for models 1,2,3



Pattern for models 4,5,6



Model 1



Fabric



Manipulation Techniques



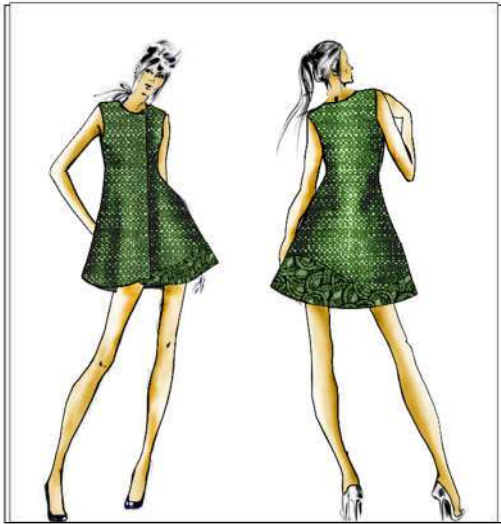
Model 2



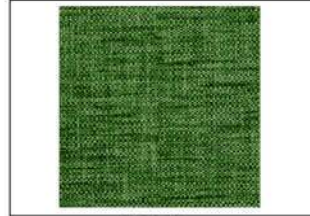
Fabric



Manipulation Techniques



Model 3



Fabric



Manipulation Techniques



Model 4



Fabric



Manipulation Techniques



Model 5



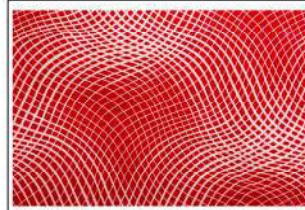
Fabric



Manipulation Techniques



Model 6



Fabric



Manipulation Techniques

Design Outcomes

- The Collection developed as part of practice-led sustainable design research, demonstrates that design practice can offer a unique strategy to engage with sustainable design by designing within self-imposed limitations.

- In this case, garment cutting was minimized through design and fabric manipulation was used to explore and develop any possible waste elements so that the potential 'waste' sections become part of the finished garment.

- Most garments within the collection are constructed using straight sewing with a basic industrial machine and therefore minimizes the capital investment required to purchase expensive specialist machinery.

- Garments have also been designed to have flexible sizing or can be 'graded' through a formula while cutting (rather than requiring a separate cardboard pattern for each size). This is a different approach to thinking about waste within the garment life-cycle as well as within the textiles life-cycle.

In contrast to the less constructed pieces, these are investment pieces that aim for longevity, to last across many fashion seasons, and be worn until the textiles are no longer viable.

- The collection demonstrates the foundations of a fashion practice that can be enacted within commercial and social environments to build more sustainable fashion systems, with low start-up costs and potential to build self-employment business models through design. In summary, this research resulted in the development of a sustainable design philosophy that attends to the wastefulness within the environmental, social and economic aspects of unsustainable fashion production.

Validity and reliability of search tools

Design evaluation questionnaire

Questionnaire Reliability

Means the ability of the questionnaire to measure what is being measured.

Reliability using internal consistency between the total degree of each axis and the overall score of the questionnaire

Reliability was calculated using internal consistency by calculating the correlation coefficient (Pearson correlation coefficient) between the total score of each axis (extent of achievement of the aesthetic side, extent of achievement of the functional aspect, extent of sustainability in design) and the overall score of the questionnaire. and the following table illustrates this:

Axis	correlation	Significance
The first axis: the achievement of the aesthetic side	0.748	0.01
The second axis: the achievement of the functional aspect	0.855	0.01
The third axis: Sustainability in Design	0.912	0.01

Table (1) The correlation coefficients between the degree of each axis and the degree of the questionnaire

It is clear from the table that correlation coefficients are all significant at the level of (0.01) for its approach to one, which indicates the sincerity and homogeneity of the axes of the questionnaire.

Reliability:

Means the accuracy of the test in the measurement and observation, and the inconsistency with itself, consistent and consistent in the information provided to us on the behavior of the examinee, the ratio between the degree variation on the scale that indicate the actual performance of the examinees, and calculated stability by:

- 1- Alpha Cronbach
- 2- Split-half method

Axis	Midterm split	Alpha coefficient
The first axis: the achievement of the aesthetic side	0.912 – 0.823	0.864
The second axis: the achievement of the functional aspect	0.830 – 0.746	0.783
The third axis: Sustainability in Design	0.957 – 0.866	0.900
Stability of the whole questionnaire	0.870 – 0.780	0.821

Table (2) Stability coefficient values for the questionnaire axes

It is clear from the previous table that all values of stability coefficients: alpha coefficient, midterm split, function at level 0.01 indicating the stability of the questionnaire.

Results:

First Hypothesis:

There are statistically significant differences between the six designs in the extent of achieving the aesthetic side according to the opinions of specialists

To investigate this hypothesis, the variance analysis of the mean scores of the six designs was calculated in terms of the extent to which the aesthetic aspect was achieved according to the opinions of the specialists.

The aesthetic side	Squares sum	Squares average	Free degrees	(F) value	Significance
Between groups	390.459	78.092	5	37.553	0.01
Inside groups	112.292	2.079	54		
Total	502.751		59		

Table (r) Analysis of the variance of the mean scores of the six designs in the range

Achieving the aesthetic side according to the opinions of specialists

The value of F is 37.553, which is statistically significant at (0.01), indicating that there are differences between the six designs in the extent of achieving the aesthetic side according to the opinions of

the specialists. To know the direction of significance, the following table illustrates this:

The aesthetic side	First design 15.030	Second design = 8.200	Third design 20.550	Fourth design 13.480	Fifth design 18.130	Sixth design 11.270
First design	-					
Second design	6.830**	-				
Third design	5.520**	12.350**	-			
Fourth design	1.550	5.280**	7.070**	-		
Fifth design	3.100**	9.930**	2.420*	4.650**	-	
Sixth design	3.760**	3.070**	9.280**	2.210*	6.860**	-

Table (4) LSD test for multiple comparisons

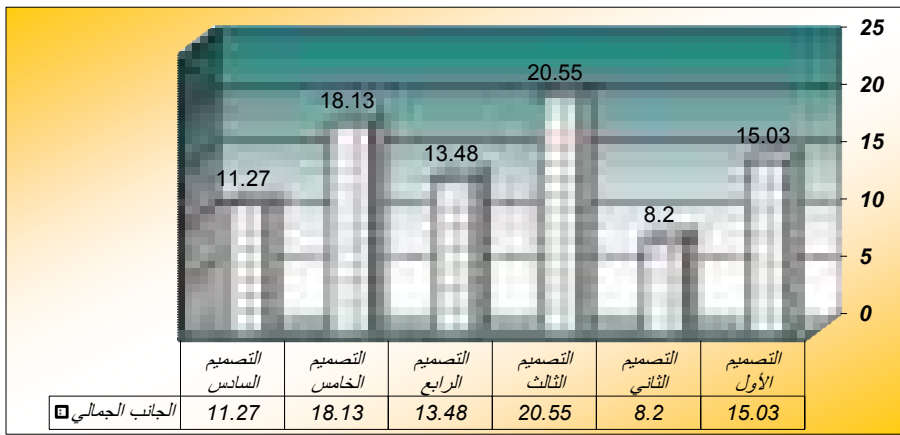


Figure (١) shows the average scores of the six designs in the range Achieving the aesthetic side according to the opinions of specialists

From Table (4) and Figure (1) shows that:

1 - There are statistically significant differences between the six designs at the level of significance 0.01, we find that the third design was the best designs in achieving the aesthetic side

according to the views of specialists, followed by the fifth design, then the first design, then the fourth design, and then the sixth design, and finally the second design.

2 - There are also differences at the level of significance 0.05 between the third design and the fifth design in favor of the third design, and there are differences at the level of significance 0.05 between the fourth design and the sixth design in favor of the fourth design.

3. While there are no differences between the first design and the fourth design.

Second Hypothesis:

There are statistically significant differences between the six designs in the extent of achieving the functional side according to the opinions of specialists

To investigate this hypothesis, the variance analysis of the mean scores of the six designs was calculated in terms of the extent to which the functional aspect was achieved according to the opinions of the specialists.

The aesthetic side	Squares sum	Squares average	Free degrees	(F) value	Significance
Between groups	2051.015	410.203	5	26.623	0.01
Inside groups	832.015	15.408	54		
Total	2883.030		59		

Table (°) Analysis of the variance of the mean scores of the six designs in the range

Achieve the functional aspect according to the opinions of specialists
 The value of F is 26.623, which is statistically significant at (0.01), indicating that there are differences between the six designs in the extent of achieving the functional side according to the opinions of specialists. To find out the direction of significance, the following table illustrates this:

The functional side	First design 11.880	Second design = 4.893	Third design 9.860	Fourth design = 7.900	Fifth design 7.400	Sixth design 5.405
First design	-					
Second design	6.987**	-				
Third design	2.020**	4.967**	-			
Fourth design	3.980**	3.007**	*1.960	-		
Fifth design	4.480**	2.507**	2.460**	0.500	-	
Sixth design	6.475**	0.512	4.455**	2.495**	1.995*	

Table (6) LSD test for multiple comparisons

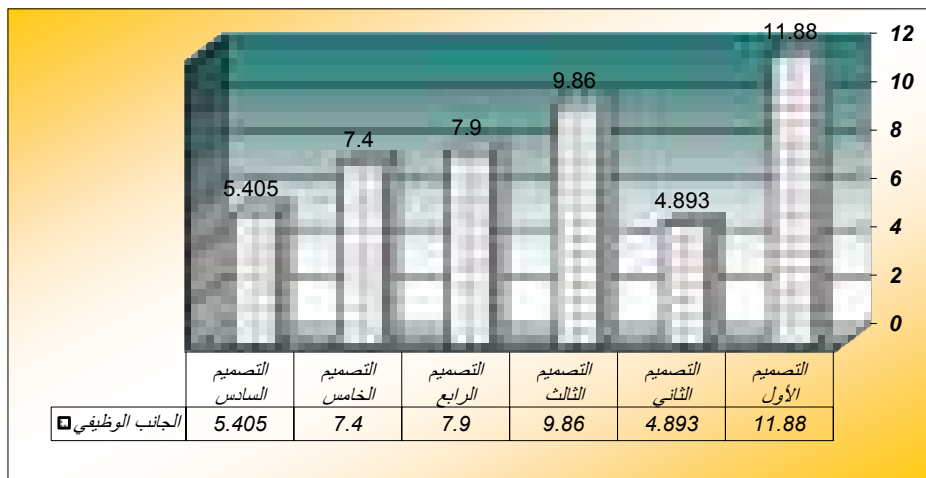


Figure (2) shows the average scores of the six designs in the range Achieve the functional aspect according to the opinions of specialists

From Table (6) and Figure (2) shows that:

1 - There are statistically significant differences between the six designs at the level of significance of 0.01, we find that the first design was the best designs in achieving the functional side according to the views of specialists, followed by the third design,

then the fourth design, then the fifth design, then the sixth design, and finally the second design.

2- There are differences at the level of significance 0.05 between the third design and the fourth design in favor of the third design, and there are differences at the level of significance 0.05 between the fifth design and the sixth design in favor of the fifth design.

3- While there are no differences between the second design and the sixth design, there are no differences between the fourth design and the fifth design.

The third hypothesis:

There are statistically significant differences between the six designs in the extent to which design sustainability is achieved according to the opinions of specialists

To investigate this hypothesis, the variance analysis of the mean scores of the six designs was calculated to determine the sustainability of the design according to the opinions of the specialists. The following table illustrates this:

Design sustainability	Squares sum	Squares average	Free degrees	(F) value	Significance
Between groups	7216.885	1443.377	5	61.489	0.01
Inside groups	1267.579	23.474	54		
Total	8484.464		59		

Table (7) Analysis of the variance of the mean scores of the six designs in the range

Achieve sustainability in design according to the opinions of specialists
 The value of (F) was 61.489, which is statistically significant at (0.01), indicating that there are differences between the six designs in the extent of achieving design sustainability according to the opinions of the specialists. To know the direction of significance, the following table illustrates this:

Design sustainability	First design 24.070	Second design 10.080	Third design 19.640	Fourth design 20.320	Fifth design 25.990	Sixth design 14.790
First design	-					
Second design	13.990**	-				
Third design	4.430**	9.560**	-			
Fourth design	3.750**	10.240**	0.680	-		
Fifth design	1.920	15.910**	6.350**	5.670**	-	
Sixth design	9.280**	4.710**	4.850**	5.530**	11.200**	

Table (8) LSD test for multiple comparisons

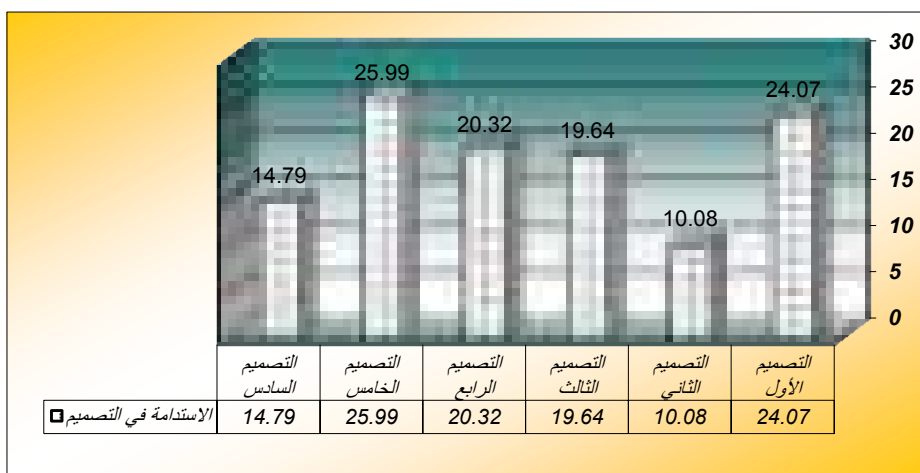


Figure (3) shows the average scores of the six designs in the range Achieve sustainability in design according to the opinions of specialists From Table (8) and Figure (3) shows that:

1 - There are statistically significant differences between the six designs at the level of significance of 0.01, we find that the fifth design was the best designs in achieving the sustainability of design according to the views of specialists, followed by the first design, then the fourth design, then the third design, and then the sixth design, and finally the second design.

2- While there are no differences between the first design and the fifth design, there are no differences between the third design and the fourth design.

Fourth hypothesis:

There are statistically significant differences between the six designs according to the opinions of specialists

To investigate this hypothesis, the variance analysis of the average scores of the six designs was computed according to the opinions of the specialists. The following table illustrates this:

Total sum	Squares sum	Squares average	Free degrees	(F) value	Significance
Between groups	1012.043	202.409	5	45.732	0.01
Inside groups	239.004	4.426	54		
Total	1251.047		59		

Table (9) Analysis of the variance of the mean scores of the six designs according to the opinions of specialists

The value of F is 45,732, which is statistically significant at 0.01, indicating that there are differences between the six designs according to the opinions of the specialists. To know the direction of significance, the LSD test was used for multiple comparisons.

Total sum	First design 24.070	Second design =10.080	Third design 19.640	Fourth design 20.320	Fifth design 25.990	Sixth design 14.790
First design	-					
Second design	27.807**	-				
Third design	0.930	26.877**	-			
Fourth design	9.280**	18.527**	8.350**	-		
Fifth design	0.540	28.347**	1.470*	9.820**	-	
Sixth design	19.515**	8.292**	18.585**	10.235**	20.055**	

Table (10) LSD test for multiple comparisons

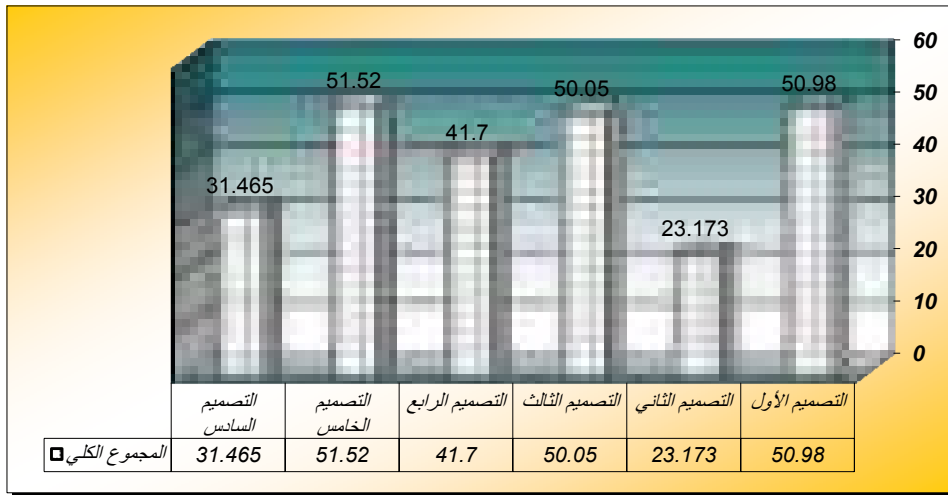


Figure (٤) shows the average scores of the six designs according to the opinions of the specialists

From Table (١٠) and Figure (٤) shows that:

- 1 - There are statistically significant differences between the six designs at the level of significance of 0.01, we find that the fifth design was the best designs according to the views of specialists, followed by the first design, then the third design, then the fourth design, and then the sixth design, and finally the second design.
- 2 - There are differences at the level of significance 0.05 between the third design and the fifth design in favor of the fifth design.
3. While there are no differences between the first design and the third design, there are no differences between the first design and the fifth design.

Results:

- Zero-waste fashion design challenges traditional ways of designing while facilitating innovative ways to design and fresh aesthetics to emerge.
- Zero-waste fashion design can also lead fashion designers to consider and apply other sustainable practices.
- Zero-waste fashion design serves as a compelling example of how to merge the skills of fashion design and pattern making while also bearing in mind sustainability and aesthetics.
- Zero-waste pattern cutting is a practical and experimental method by which to advance sustainable fashion. It can also be combined with other textile design methods, such as printing, fabric manipulation or any forms of experimental sustainable fashion.
- Most of all zero-waste fashion design can change fashion designers' attitudes towards more respectful resource use.
- This study demonstrates that zero-waste fashion design generates new opportunities for fashion design to engage with fashion manufacture that may not currently exist.
- This study calls for fashion design to consider using of fabric manipulation techniques to exploit the cutting waste, as an integral part of the fashion design process. Such an approach to fashion design creates new opportunities for the fashion industry and fashion design education.

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