

Employing Digital Printing Technology in Integrating Design and Production Processes for Adolescent Girls' Clothes

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Abstract - Through the technological development in the apparel industry and attention to small and medium enterprises, there was a need to simplify the manufacturing processes, due to SMEs' relative lack of awareness, expertise and long-term strategic vision, as well as resources and ability to divert skilled personnel from their normal day-to-day tasks. The present research aims to integrate design and pattern making (pattern-grading-marker) processes which represent the major phases in the fashion garment life-cycle. Inkjet digital printing technique was used to print the pattern marker with the decorative designs on fabrics that are suitable to girls in late adolescence. Najd region motifs were used as an inspiration resource to add aesthetics to the proposed designs, taking into account the 2020 fashion trends. Innovating packages were designed with clear manufacturing instructions to make it easier for small and medium enterprises to assemble parts of the pattern, sewing and finishing products.

Keywords: Manufacturing processes, Small and Medium enterprises, Inkjet digital printing, Adolescence, Fashion design, Pattern making, Najd motifs.

I. INTRODUCTION

Apparel industries contribute significantly towards national economy of many countries. Although the apparel industry is global in nature, the manufacturing facilities from developed countries are shifting to developing countries to reduce the labor cost [1]. The apparel sector is a major source of exports and employment in many developing countries [2], where entrepreneur, particularly in the context Small and Medium Enterprises (SMEs) is essential for economic growth. SMEs contributes as a solution to the State's economic growth, in term of generating employment, offering innovative products [3], enhancing greater employment opportunities per

unit capital invested and aiding the development of local technology [4]. The apparel-manufacturing process evolved as an art and underwent several technical changes. The Technological advancement in apparel industry includes the use of computerized equipment (especially in design, pattern-making and cutting). [1]

SMEs' relative lack of awareness, expertise and long-term strategic vision, as well as resources and ability to divert skilled personnel from their normal day-to-day tasks [5], so the present research aims to integrate design and pattern making (pattern-grading-marker) processes which represent the major phases in the fashion garment life-cycle. Inkjet digital printing technology was used to print the pattern marker with the decorative designs on fabrics that are suitable to girls in late adolescence. Najd region motifs were used as an inspiration resource to add aesthetics to the proposed designs, taking into account the 2020 fashion trends. Innovating packages were designed with clear manufacturing instructions to make it easier for small and medium enterprises to assemble parts of the pattern, sewing and finishing products.

a) Design and Pattern Making Process

For a fashion garment, the life-cycle begins at fiber (cradle), moving through to textile production, garment design process, manufacture, distribution [6], labeled and shipped [7], retail, use phase and eventual disposal (grave) [6]. Garment manufacturing process consists of series of different steps. These steps are broadly divided into two categories pre-production and production process. The preproduction process consists of designing the garment, pattern design, sample making, production pattern making, grading and marker making. Once the sample is approved for commercial production, final marker is made for cutting. The production process consists of cutting, stitching (preparatory and assembly) and finishing. [8]

The design process generally includes all stages involved from ideas generation to prototype development [9], Design encompasses aesthetics, formulation of design strategies, how and what to design, and a plan of organization to make it happen. Fashion designers are problem solvers with many responsibilities and roles in the product development process, one could summarize the designer's role is giving the customer what they want or need in the future season(s) by solving any issues related to those future wants and needs with creative design, and then organizing a plan of action to make it happen. [10] Fashion designer considers many aspects during the design process. Based on a given demographic and body form, an apparel designer thinks about the feasibility of production, which includes the technical structure of a garment and the cost of production in addition to the creating of a pleasing physical form for the garment. Fashion designer must also dwell in the shared context with customers in order to please their aesthetic desires. [11]

Pattern making represents the development of two-dimensional (2D) component parts created for a styled garment. It is a craft that has evolved into a skilled technical process. Two-dimensional patterns, once created, are used as a template for cutting fabric, which when sewn together forms a 3D garment. Body measurements are a prerequisite to pattern construction [12]. For pattern grading, anthropometric data should be available for the market in which the garment is to be sold. Pattern grading is a process of enlarging or diminishing a style pattern, making it possible to obtain proper fit for all sizes without changing the title for a given compilation of anthropometric measurements that are suitable for a person whose body measurements lie within certain tolerance limits of the garment size measurements [1]. Traditionally a formulated grading method has been used to generate different sizes of a given pattern. This traditional grading method is the standard sizing system in today's apparel industry. It starts with a base size which is then proportionally graded to create a multiple set of sizes [13]. In garment industry, a mark planning process is used to plan for cutting process. The function of this process is to generate a set of markers which are used as cutting guidelines or cutting patterns in a cutting process. Therefore marker planning process can be defined as the process of arranging all the patterns of the component parts of one or more garments on a piece of paper. [14]

The designer produces a sketch, which the patternmaker uses to create a pattern. The fashion designer may also be responsible for the pattern. Relationships between designers and patternmakers are diverse; whilst the communication is simplified into four types, combinations of the four probably take place. In some instances the designer may make the

pattern, but may use sketches, draping or existing garments as conceptual tools preceding the patternmaking process. [15]

Integrated CAD/CAM systems are playing an increasing role in manufacturing environments [16]. In the apparel industry, CAD systems are mainly used in various processes such as garment design, pattern preparation, pattern grading and marker making. CAD systems are extensively used during the preproduction phase, which is labor-intensive [17]. The apparel industry is the most skilled labor-dependent industry and any cost saving through new computer-aided design (CAD) technologies has become a requirement in gaining a competitive advantage. [18]

b) Inkjet Digital Printing of Textiles

Ink jet is a technology that enables the delivery of liquid ink to a medium whereby only the ink drops make contact with the medium. It is therefore a non-impact printing method [19]. Recent years have seen an increasing interest in the application of ink jet printing in the textile market. This technique offers benefits such as non-contact, speed, flexibility, creativity, cleanliness [20]. A digital printing system for application on textiles is an integration of four components, namely the inkjet head, ink chemistry, media and the color management software. For each component, various technologies and supplies exist. Based on the choice of level of technology available [21]. In spite of the challenges facing the development of inkjet printing technology for textiles that would have commercial implications for industry, this technology has attracted attention in recent years. This is due to associated advantages over the traditional flat and rotary screen printing and roller printing technologies. Ink formulation is one of the most important factors affecting print quality and reliability owing to the dependence of the jettability of the ink by the print head on the physical properties of the ink, which are optimized to comply with the print head in use and to provide practically acceptable ink storage stability. [22]

Ink jet technology is typically classified in two large classes: Continuous Ink Jet (CIJ) and Drop-on-demand Ink Jet. In CIJ, ink is squirted through nozzles at a constant speed by applying a constant pressure. In DOD ink jet, drops are ejected only when needed to form the image. The two main drop ejector mechanisms used to generate drops are piezoelectric ink jet (PIJ) and thermal ink jet (TIJ) [19]. Inks for fabric printing are usually classified into two categories of dye and pigment inks. Pigment inks show more environmental advantages and have shorter processes than dye inks because the final products printed can be achieved by simple heat curing of the printed fabrics without steaming and washing.

However, the sharpness of the inkjet printing images is a main factor in controlling quality of the final products. [23]

Textile printing by inkjet printing has been predicted to become more popular in the near future because it offers a simple process and inevitable benefits. Therefore, it is worthwhile investigating the print qualities of cotton fabric prints achieved through inkjet ink deposition in comparison with screen ink deposition using the same pigment dispersion systems. [24]

II. MATERIALS AND METHOD

In this research, garment life-cycle is used to explore how to integrate design and pattern making in one process.

a) Design Process

The successful designer meets the needs of consumer, who has demands on many levels, from clothes worn just not as a statement of current fashion trends but as a complex status, sex appeal and conspicuous consumption, to the more practical consideration of utility, fit, value and ease of care [25]. In adolescence, clothes, because of their symbolic function, are powerful social interaction tools. Young people who follow the accepted dress code are more likely to be accepted by their peers than are those who express their individualism. The more a person is interested in a product category, the more he or she is sensitive to brands. Of all the social groups, teenagers are one of the groups that attach the most importance to fashion and physical appearance in general [26]. The proposed designs (blouses-skirts) for girls in late adolescence were inspired from 2020 spring/summer fashion trends. They are inspired from the main themes of blouses (one shoulder blouses-short sleeved blouses-bulky sleeve blouses) and skirts (wrap and asymmetry skirts-A-shaped skirts).

To add aesthetics to the proposed designs, decorative designs were created. Which inspired from the Najd region motifs at Saudi Arabia. The Najd, or “highland”, is a flat plateau spreading over the central part of the Arabian Peninsula. It sits in geographical isolation and in the past was inaccessible because it is flanked to the west by the mountains of Hijaz, while the other three sides are bordered by a desert wilderness. [27] The indigenous art is made of decomposable materials. It used checks, squares, circles, stripes and other geometrical patterns during the period of development. In addition, floral shapes were incorporated into elaborate patterns. The decoration, ornamentation, and colour motifs and spaces are classified in terms of sematic meaning into: Primitive motifs-Symbolic motifs- Geometric motifs- Abstract motifs- Floral and vegetation motifs. They characterised by:

Equilibrium-Symmetry- Ramification- Repetition- Proportion. [28]

Adobe illustrator was used to assist in creation, modification, optimization, and colouring the proposed designs and to add the decorative designs on the proper spaces.

b) Pattern Making Process

GRAFIS CAD software was used to create pattern pieces, grading (size range: 34-40) and marker for proposed designs. GRAFIS® clothing construction have the advantage of the construction principle. Each step is documented in a construction record and can be utilized again and again with different measurement charts (body measurements or finished measurements) to give maximum control over style development. Grading in GRAFIS® is not carried out as standard grade rule grading but as a new calculation of the entire construction. Grading ensues automatically based on measurement charts. The stand-alone lay planning program included in GRAFIS® CAD It offers an uncomplicated transition from pattern construction to laying out pattern pieces for cutting (marker).

The marker of proposed design was transferred to adobe illustrator program to color each pattern piece for certain size with the same color. The name of each piece and its size was written on the sewing allowance for each piece, which help in collecting the all pattern pieces for each size together. The marker dimensions (width, length) and the size rang were written on the end of the fabric with the same color used in coloring pattern pieces for each size. Adobe illustrator program also used to assist in creating the decorative designs which inspired by Najd motifs and placing them on the proper spaces on pattern pieces for each size.

C) Digital Printing Process

Hybrid Anapurna LED machine was used to print the marker of proposed designs on fabrics, as shown in figure 1. It characterized by High-speed 4/6-color + white hybrid UV LED-curable inkjet system with a printing width from 1.65 to 3.2 m, high-quality printing on a wide range of uncoated rigid media as well as on roll media, Robust industrial engineered concept fit for sustained higher workloads, UV LED lamps that enable printing on thermally sensitive materials and save costs, time and the environment, High productivity—enhanced even more by multiple board printing and/or automatic board feeding, UV LED ink for fast drying, material versatility and a very wide color gamut, Printing pre-, sandwich and post-white in one run, Thin Ink Layer technology for the lowest ink consumption in the market, and Powered by Asanti workflow software.

Synthetic fabric (polyester) and blended fabrics (cotton/polyester-polyester/viscose) were used for printing the marker of proposed designs.



Figure 1: Hybrid Anapurna LED machine during printing the marker of one of the research product

d) Packaging Process

It is an important part of manufacturing process. Carton boxes with leather cover were created to use in packing the printed fabrics. The proposed design, the marker of the proposed design, data about the printed fabric (description-season-product no.-fabrication- fabric width- marker length-size rang- fabric color- printing method- color way) were printed on the outer surface of the box, as shown in figure 2. Inside the box, the printed fabric was placed in a plastic bag, as shown in figure 3, and a paper that included the proposed design in a small scale, pattern draft, machines and stitches that used in sewing process, and the product construction, as shown in figure 4.



Figure 3: printed fabric was packed in a plastic bag

Description	Blouse	Product no.	#01
Season	SS 2020	Fabrication	97%Polyester 3%Elastane (Satin)
Fabric Width	1.4m	Marker length	4.66m
Size range	34-40	Printing method	Inkjet printing

Machines	Stitch Type	Stitch Shape
Flat sewing machine-single needle two threads	301 (Lockstitch)	
Overlock machine -twin needles 5-thread	516 (Safety stitch)	
Overlock machine -single needles 3-thread	504 (Overedge)	

No.	Operation	Stitch Type	Machine
1	Hemming ruffle cuts	EF8	504 Overedge stitch
2	Ironing the placket and biting 3x3cm	<input type="checkbox"/>	<input type="checkbox"/>
3	Shoulder overlock (right side)	L5C	516 Safety stitch
4	Shoulder overlock (left side)	L5C	516 Safety stitch
5	Sewing center front line	L5C	516 Safety stitch
6	Seam and installing the V-cut	SSa	301 Lockstitch
7	Sewing lining shoulder with V-cut lining shoulder	SSa	301 Lockstitch
8	Hemming lining edges	L5C	504 Overedge stitch
9	Sewing the lining with front and back neck hole then hemming selvage	SSa	301 Lockstitch
10	Installing ruffle cuts	L5C	516 Safety stitch
11	Sewing sleeve with bodice right side	L5C	516 Safety stitch
12	Sewing sleeve with bodice left side	L5C	516 Safety stitch
13	Sewing sleeve hem 1.2	SSa	301 Lockstitch
14	Sewing side seam right and left side	L5C	516 Safety stitch
15	Hemming (folding edge)	SSa	301 Lockstitch
16	Sewing button holes	<input type="checkbox"/>	<input type="checkbox"/>
17	Installing buttons	<input type="checkbox"/>	<input type="checkbox"/>
18	Ironing Blouse	<input type="checkbox"/>	<input type="checkbox"/>
19	Packing	<input type="checkbox"/>	<input type="checkbox"/>

Figure 4: Manufacturing instructions paper

To evaluate the products and be sure that the research aims were achieved, the questionnaire was designed (Appendix I), which was composed of four sections. Section I, the product aesthetics, section II, the product functionality, section III, the product marketing, section IV, the products packaging. Respondents (owners of small and medium enterprises) were required to answer 32 questions, and were asked to rate the degree of their agreement. A five-point Likert-scale was used, in which “1” represented “strongly disagree” and “5” represented “strongly agree”.

After designing and constructing the questionnaire, 10 participants (professor and associate professor in the field of fashion design) were involved in a pilot test to guard against obtaining invalid or irrelevant data. A total of 10 sets of data were collected from the completed questionnaires and



Figure 2: Packaging box

analyzed, and the results were highly desirable. Comments about the structure, wording and length of the questionnaire were all positive. The pilot test data were analyzed using reliability tests (Cronbach's α), correlation analysis and a regression test. All of the internal reliability estimate results were larger than 0.7. Therefore, the pilot test had a high internal reliability and consistency. The process and results of the pilot testing confirmed the reliability of the questionnaire.

III. RESULTS AND DISCUSSIONS

a) Presentation of the research products

The eight research products were presented, as follows: Each proposed design was presented in an appropriate layout including the source of inspiration. Then the marker of each design which was printed on fabric by using ink jet digital printing method, finally the packaging for each product.



Figure 5: Proposed design 1



Figure 6: product 1 (blouse)



Figure 7: Packaging of product 1 (outside the box)



Figure 8: Packaging of product 1 (inside the box)



Figure 9: Proposed design 2



Figure 10: product 2 (blouse)



Figure 11: Packaging of product 2 (outside the box)



Figure 12: Packaging of product 2 (inside the box)



Figure 13: Proposed design 3



Figure 14: product 3 (skirt)



Figure 15: Packaging of product 3 (outside the box)



Figure 16: Packaging of product 3 (inside the box)



Figure 17: Proposed design 4



Figure 18: product 4 (skirt)



Figure 19: Packaging of product 4 (outside the box)



Figure 20: Packaging of product 4 (inside the box)



Figure 21: Proposed design 5



Figure 22: product 5 (skirt)



Figure 23: Packaging of product 5 (outside the box)



Figure 24: Packaging of product 5 (inside the box)



Figure 25: Proposed design 6



Figure 26: product 6 (skirt)



Figure 27: Packaging of product 6 (outside the box)



Figure 28: Packaging of product 6 (inside the box)



Figure 29: Proposed design 7



Figure 30: product 7 (blouse)

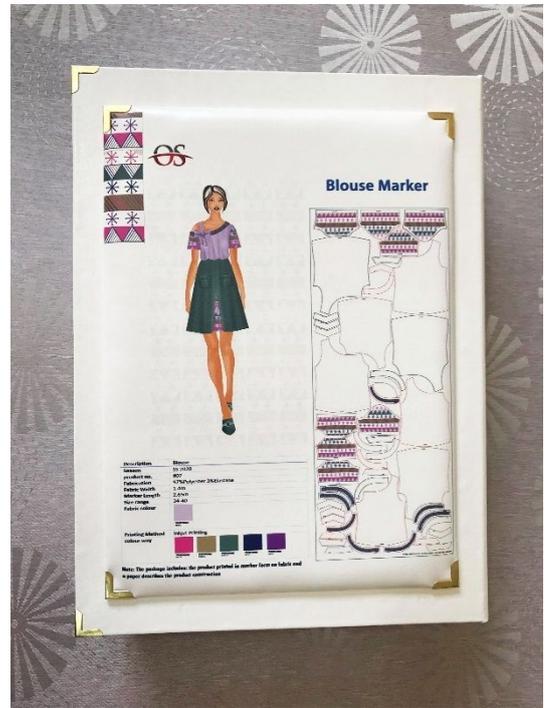


Figure 31: Packaging of product 7 (outside the box)



Figure 32: Packaging of product 7 (inside the box)



Figure 33: Proposed design 8



Figure 34: product 8 (blouse)



Figure 35: Packaging of product 8 (outside the box)



Figure 36: Packaging of product 8 (inside the box)

b) Data analysis

A self-administered questionnaire survey was conducted, with 15 respondents (owners of small and medium enterprises). Information was collected with the respondents' knowledge, their expressed willingness and informed consent. After collecting the data, it has been analysed by IBM SPSS Statistics 25. As the first analysis, the basic features of the data has been described with the descriptive statistics to provide simple summaries about respondents. After the quantitative data collection process had been completed, data analysis began.

Section I (The product aesthetics) of the questionnaire will provide an overview of the respondents' interaction with 8 designs, as shown in table I.

TABLE I

Means and percentage of mean and responses for Section I (the product aesthetics)

Items	strongly disagree	2	3	4	strongly agree	Mean	%
1	0%	0%	1.8%	22.7%	75.5%	4.74	95%
2	0%	2.7%	9.1%	15.5%	72.7%	4.58	92%
3	0%	4.5%	13.6%	21.8%	60.0%	4.37	87%
4	0%	4.5%	16.4%	30.9%	48.2%	4.23	85%
5	0%	3.6%	20.9%	33.6%	41.8%	4.14	83%
6	0%	2.7%	8.2%	44.5%	44.5%	4.31	86%
7	0%	2.7%	6.4%	15.5%	75.5%	4.64	93%
8	0%	1.8%	2.7%	26.4%	69.1%	4.63	93%
9	0%	1.8%	5.5%	17.3%	75.5%	4.66	93%
10	0%	1.8%	5.5%	28.2%	64.5%	4.55	91%
overall						4.48	90%

According to table I, the 10 Items were positive with an overall mean score of 4.48 (% of mean = 90%). The majority of respondents agreed to with 8 designs.

The first item with the highest level of satisfaction (75.5% 'strongly agree') was 'Decoration design corresponds to the fashion design lines'. This also had the highest mean score (M = 4.74 and 95%). The second highest rated item (75.5% 'strongly agree'; M = 4.66) was 'This decorative design achieves the aesthetic values of the Najd region's traditional motifs and formulates them with a modern vision to emphasize Saudi identity and heritage'. This also had the

highest mean score (M = 4.66 and 93%). The third highest rated item (75.5% 'strongly agree'; M = 4.64) was 'The fashion design is innovative and suits the girl in late adolescence'. This also had the highest mean score (M = 4.64 and 93%). The fourth highest rated item (72.7% 'strongly agree'; M = 4.58) was 'Harmony is achieved between the fashion design parts'. This also had the highest mean score (M = 4.58 and 92%). The fifth highest rated item (69.1% 'strongly agree'; M = 4.63) was 'The digital printing method is compatible with the decorative design'. This also had the highest mean score (M = 4.63 and 93%). The sixth highest rated item (64.5% 'strongly agree'; M = 4.55) was 'The fashion design is in line with the 2020 spring/summer fashion trends'. This also had the highest mean score (M = 4.55 and 91%). The seventh highest rated item (60% 'strongly agree'; M = 4.37) was 'The color range corresponds to both, decorative and fashion design'. This also had the highest mean score (M = 4.37 and 87%). The eighth highest rated item (48.2% 'strongly agree'; M = 4.23) was 'The product achieves aesthetic performance through printing the pattern pieces and marker on fabrics'. This also had the highest mean score (M = 4.23 and 85%). The ninth highest rated item (44.5% 'strongly agree'; M = 4.31) was 'The fabric suits to the design lines'. This also had the highest mean score (M = 4.31 and 86%). The tenth highest rated item (42% 'strongly agree'; M = 4.14) was 'The fashion design is unique'. This also had the highest mean score (M = 4.14 and 83%).

Section II (The product aesthetics) of the questionnaire will provide an overview of the respondents' interaction with 8 designs, as shown in table II.

TABLE II

Means and percentage of mean and responses for Section II (the product functionality)

Items	strongly disagree	2	3	4	strongly agree	Mean	%
11	0%	0%	0%	0%	100%	5	100%
12	0%	0%	13.33%	40%	46.67%	4.33	86.67%
13	0%	0%	6.67%	40%	53.33%	4.47	89.33%
14	0%	0%	0%	0%	100%	5	100%
15	0%	0%	6.67%	0%	93.33%	4.87	97.33%
16	0%	0%	6.67%	33.33%	60%	4.53	90.67%
17	0%	0%	6.67%	0%	93.33%	4.87	97.33%
18	0%	0%	6.67%	0%	93.33%	4.87	97.33%

19	0%	0%	6.67%	6.67%	86.66 %	4.8	96.0 0%
20	0%	0%	13.33 %	6.67%	80%	4.67	93.3 3%
overall						4.74	94.8 %

According to table II, the 10 Items were positive with an overall mean score of 4.74 (% of mean = 94.8%). The majority of respondents agreed to with 8designs.

The First item with the highest level of satisfaction (100 ‘strongly agree’) was ‘The fabric is compatible with the functionality of the fashion design’. This also had the highest mean score (M = 5 and 100%). The second highest rated item (100% ‘strongly agree’; M = 5) was ‘The motifs used in creating the decorative design contribute to emphasize the style that suits to girls in late adolescence’. This also had the highest mean score (M = 5 and 100%). The third highest rated item (93.33% ‘strongly agree’; M = 4.87) was ‘The highest efficiency is achieved for the marker of the pattern pieces of the design, which was printed on the fabric using the digital printing method so that it is partially implemented for manufacturing’. 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 product contributes to assisting non-specialists in the preparation of the design and pattern’. 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 ‘Digital printing technology is a perfect method to print the pattern pieces with efficient marker on the fabric’. 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 ‘The product simplifies manufacturing processes so that it is partially implemented for manufacturing’. 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 ‘The manufacturing instructions which are provided with the product facilitate the sewing and finishing process’. 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 ‘The product contributes to solving the problem of unemployment’. 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 ‘The product simplifies manufacturing processes so that it is partially implemented for manufacturing’. 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 costumer gains the added value through purchasing this product’. This also had the highest mean score (M = 4.33 and 86.67%).

Section III (The product marketing) of the questionnaire will provide an overview of the respondents' interaction with 8 designs, as shown in table III.

TABLE III
Means and percentage of mean and responses for Section II (the product marketing)

Items	strongly disagree	2	3	4	strongly agree	Mean	%
21	0%	0%	0%	0%	100%	5	100 %
22	0%	0%	1.8%	22.7%	75.5%	4.74	95%
23	0%	0%	0%	0%	100%	5	100 %
24	0%	2.7 %	6.4%	15.5%	75.5%	4.64	93%
25	0%	0%	6.67%	0%	93.33 %	4.87	97.3 3%
26	0%	0%	6.67%	0%	93.33 %	4.87	97.3 3%
27	0%	0%	6.67%	6.67%	86.66 %	4.8	96.0 0%
overall						4.85	97%

According to table III, the 7Items were positive with an overall mean score of 4.85 (% of mean = 97%). The majority of respondents agreed to with 8designs.

The First item with the highest level of satisfaction (100 ‘strongly agree’) was ‘The product contributes to feed the market with the two main processes of manufacturing (design and pattern making)’. This also had the highest mean score (M = 5 and 100%). The second highest rated item (100% ‘strongly agree’; M = 5) was ‘The product meets the costumer’s (girls in late adolescence) desires’. This also had the highest mean score (M = 5 and 100%). The third highest rated item (93.33% ‘strongly agree’; M = 4.87) was ‘The product saves time for small and medium entrepreneurs by implementing it partially, so it can be manufactured on demand at the proper speed and on time’. 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 product achieves the design quality and accuracy of the pattern, which is designed to meet the desires of the customer’. This also had the highest mean score (M = 4.87 and 97.33%). The fifth highest rated item (86.66% ‘strongly agree’; M = 4.8) was ‘The product achieves quick response to customer's requests’. This also had the highest mean score (M = 4.8 and 96%). The sixth highest rated item (75.5% ‘strongly agree’; M = 4.74) was ‘The product is one of the suitable solutions for the obstacles faced by small and medium enterprises in the field of fashion industry’. This also had the highest mean score (M = 4.74 and 95.00%). The

seventh highest rated item (75.5% ‘strongly agree’; M = 4.64) was ‘The product is an atypical commodity that conforms to the customer’s demands in the market’. This also had the highest mean score (M = 4.64 and 93%).

Section IV (The product packaging) of the questionnaire will provide an overview of the respondents' interaction with 8 designs, as shown in table IV.

TABLE IV
Means and percentage of mean and responses for Section IV (the product packaging)

Items	strongly disagree	2	3	4	strongly agree	Mean	%
28	0%	1.8 %	5.5%	17.3%	75.5%	4.66	93%
29	0%	0%	0%	0%	100%	5	100 %
30	0%	0%	0%	0%	100%	5	100 %
31	0%	0%	6.67%	0%	93.33 %	4.87	97.3 3%
32	0%	0%	0%	0%	100%	5	100 %
overall						4.9	98%

According to table IV, the 5 Items were positive with an overall mean score of 4.9 (% of mean = 98%). The majority of respondents agreed to with 8 designs.

The First item with the highest level of satisfaction (100% ‘strongly agree’) was ‘The packaging design is an attractive element for the customer to purchase’. This also had the highest mean score (M = 5 and 100%). The second highest rated item (100% ‘strongly agree’; M = 5) was ‘The product description data and construction included in packaging was presented in a proper way’. This also had the highest mean score (M = 5 and 100%). The third highest rated item (100% ‘strongly agree’; M = 5) was ‘The product packaging is attractive to the costumer and meets his purchasing desires’. This also had the highest mean score (M = 5 and 100%). The fourth highest rated item (93.33% ‘strongly agree’; M = 4.87) was ‘The product construction and types of machines and stitches included in the product packaging is clear and understandable’. This also had the highest mean score (M = 4.87 and 97.33%). The fifth highest rated item (75.5% ‘strongly agree’; M = 4.6) was ‘The packaging design enhances the visual appearance of the product’. This also had the highest mean score (M = 4.66 and 93%).

TABLE V
Means and percentage of mean for questionnaire sections

Sections	Mean	%
I	4.48	90%
II	4.74	94.8%
III	4.85	97%
IV	4.9	98%

According to table V, the 4 questionnaire sections were positive with an overall mean score of 4.48 (% of mean = 90%) for section I (the product aesthetics), overall mean score of 4.74 (% of mean = 94.8%) for section II (the product functionality), an overall mean score of 4.85 (% of mean = 97%) for section III (the product marketing), an overall mean score of 4.9 (% of mean = 98%) for section IV (the product packaging), The majority of respondents agreed to with 8 designs, as shown in figure 36.

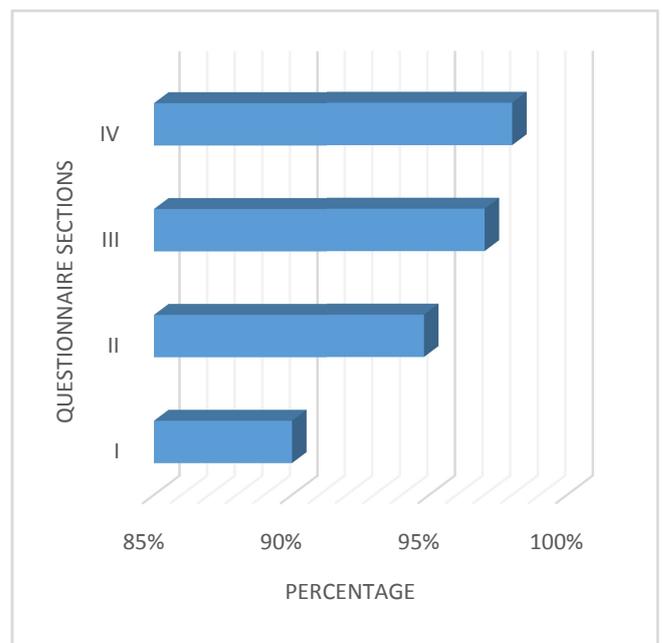


Figure 36: percentage of mean and respondents' interaction with questionnaire sections

Using one-way ANOVA, the F statistic test whether the designs are all equal, that there are differences among the means of the 8 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 8 designs for 15 respondents. There were statistically significant differences based on sum of all questions between 8 designs for 15 respondents.

TABLE VI
Analysis of variance (ANOVA)

design	N	Mean	Std. Deviation	rank	F	Sig.
1	15	48.00	1.844	2	5.916	.000
2	15	47.00	3.847	3		
3	15	44.27	4.519	4		
4	15	41.55	6.056	7		
5	15	39.45	4.967	8		
6	15	48.27	1.009	1		
7	15	44.18	2.822	5		
8	15	43.55	3.934	6		

Table VI shows the descriptive statistics of all design for all respondents.

For "Design 6" has the highest mean of 48.27 (=96.5%). Subsequently, it followed by Design 1 and Design 2. However, Design 5 has the lowest mean which 39.45 (=78.9%).

As shown in Table VI, $F= 5.916$; $p= 0.000$. The differences according to respondents regarding the reading frequency of and the importance assign to various design. It was found that there is a statistical significance by integrating design and pattern making (pattern-grading-marker) in one process.

IV. CONCLUSION

Small and Medium Enterprises (SMEs) can be seen as a safety valve in national economic recovery. SMEs' role in the rapid growth economic and employment is expected to be a starting point for efforts Government moves production sector [3]. SMEs lacking expertise and skilled worker in design and pattern making processes to comply with the customer's needs.

Integrating design and pattern making in one process through printing the marker of designs on fabrics simplifies the garment manufacturing processes, shortening the garment life-cycle and helps in providing the SMEs with products that partly implemented for manufacturing.

Inkjet printing technology gives high quality textile prints with unlimited colour variations and no repeat restrictions. It is a perfect technology for printing the research products because of its speed, quality and advantages over the traditional flat and rotary screen printing and roller printing technologies.

According to data analysis, the 4 questionnaire sections were positive with an overall mean score of 4.48 (% of mean = 90%) for section I (the product aesthetics), overall mean score of 4.74 (% of mean = 94.8%) for section II (the product functionality), an overall mean score of 4.85 (% of mean = 97%) for section III (the product marketing), an overall mean score of 4.9 (% of mean = 98%) for section IV (the product packaging). The majority of respondents agreed to with 8 designs. "Design 6" has the highest mean of 48.27 (=96.5%). Subsequently, it followed by Design 1 and Design 2. However, Design 5 has the lowest mean which 39.45 (=78.9%).

By using Statistical analysis of respondent's opinions, it was found that there are differences of statistical significances which confirms that the research aim "integrate design and pattern making (pattern-grading-marker) processes which represent the major phases in the fashion garment life-cycle by using Inkjet digital printing technology to print the pattern marker with the decorative designs on fabrics that are suitable to girls in late adolescence", is achieved.

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Appendix I: The research questionnaire

no	Items	Strongly disagree 1	Disagree 2	Uncertain 3	Agree 4	Strongly agree 5
Section I: the product aesthetics						
1	Decoration design corresponds to the fashion design lines.					
2	Harmony is achieved between the fashion design parts.					
3	The color range corresponds to both, decorative and fashion design.					
4	The product achieves aesthetic performance through printing the pattern pieces and marker on fabrics.					
5	The fashion design is unique.					
6	The fabric suits to the design lines.					
7	The fashion design is innovative and suits the girl in late adolescence.					
8	The digital printing method is compatible with the decorative design					
9	This decorative design achieves the aesthetic values of the Najd region's traditional motifs and formulates them with a modern vision to emphasize Saudi identity and heritage.					
10	The fashion design is in line with the 2020 spring/summer fashion trends.					
Section II: the product functionality						
11	The fabric is compatible with the functionality of the fashion design.					
12	The customer gains the added value through purchasing this product.					
13	The product achieves functional performance through printing the pattern pieces and the marker on fabric.					
14	The motifs used in creating the decorative design contribute to emphasize the style that suits to girls in late adolescence.					
15	The highest efficiency is achieved for the marker of the pattern pieces of the design, which was printed on the fabric using the digital printing method so that it is partially implemented for manufacturing.					
16	The product contributes to solving the problem of unemployment.					
17	The product contributes to assisting non-specialists in the preparation of the design and pattern.					
18	Digital printing technology is a perfect method to print the pattern pieces with efficient marker on the fabric.					
19	The product simplifies manufacturing processes so that it is partially implemented for manufacturing.					
20	The manufacturing instructions which are provided with the product facilitate the sewing and finishing process.					
Section III: the product marketing						
21	The product contributes to feed the market with the two main processes of manufacturing (design and pattern making).					
22	The product is one of the suitable solutions for the obstacles faced by					

	small and medium enterprises in the field of fashion industry.					
23	The product meets the costumer’s (girls in late adolescence) desires.					
24	The product is an atypical commodity that conforms to the customer’s demands in the market.					
25	The product saves time for small and medium entrepreneurs by implementing it partially, so it can be manufactured on demand at the proper speed and on time					
26	The product achieves the design quality and accuracy of the pattern, which is designed to meet the desires of the customer.					
27	The product achieves quick response to customer's requests.					
Section IV: the product packaging						
28	The packaging design enhances the visual appearance of the product.					
29	The packaging design is an attractive element for the customer to purchase.					
30	The product description data and construction included in packaging was presented in a proper way.					
31	The product construction and types of machines and stitches included in the product packaging is clear and understandable					
32	The product packaging is attractive to the costumer and meets his purchasing desires.					
