Enhancing the process of prototype development in the Egyptian apparel industry

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Abstract:
The purpose of this research is to develop a new and improved system for prototype development within the Egyptian industry, the suggested system supposed to shorten the times required for the prototyping process, in addition to improving the appearance, and fit goodness of the prototypes results in final products improvements and better market advantage for Egyptian manufactories.
For the development of this research, a number of five Egyptian small and medium apparel manufactories were investigated for their current prototype development methods, initial field observations were made within each factory, with participation of the corresponding prototype employee in each factory. A model of the current prototypes developing method in the Egyptian factories was illustrated after investigation, this model was then analysed. A new suggested model for prototype development was developed.
A number of two prototypes were made using the current methods, then another two prototypes were developed using suggested system, observations were collected of times required for the four prototypes development before and after applying the new system, the fit goodness of the four prototypes were evaluated as well.
Data were analysed using the f-distribution test followed by t-test, both of the testes indicated a significant difference between the observations before and after applying the new system, the new prototype development system helped shortening the times required for the process, in addition to improving the fit goodness of the process results.
Using the suggested system, the apparel industry can enjoy cost-cutting effects by using this suggested system. A company does not have to spend money and time repeating the prototyping process to apply too many fixes, moreover, applying this suggested system supposed to help them acquiring competition advantages for their improved fit, as well as the ability to apply a wider variety of fashion features into their garments.

Keywords:
- Prototype,
- pattern cutting,
- Egyptian apparel Industry
- sample making,
- garment
- prototype development

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Introduction

In apparel industry, the quality evaluation of the product depends more on human aesthetic sense than on the optimum physical performance (Kim and Park, 2007). Apparel fitting and appearance are important factors in the decision making process of the customers. That is why one of the most important factors for the apparel production and retail industry is to achieve well-fitting garments on 3D human body forms (Strydom and Klerk, 2006). A well-fitted garment will give the wearer a harmonious look and a feeling of ease (Bond et al, 2000).

Efficient and extensive use of prototypes can make a difference in the successful entry of new products into a competitive global market (Zorriassatine et al., 2003). Prototypes are created to finalise aesthetics and ergonomics, as well as to test, evaluate and validate the functional and technical aspects of the design (Pei et al., 2010). Prototypes provide both tactile and visual evaluation of aspects including form, feel and surface finish, etc., as most products incorporate some form of human interaction, this tactile advantage should be seen as highly desirable, particularly when interacting with customers (Campbell et al., 2007).

In addition, the stage of product development and product preparation of clothes requires approximately three times the stage of consumption (Rödel et al, 2001). While, due to the market competitive pressure, it is imperative to reduce time and costs of product development in the clothing industry (Hlaing et al, 2013). Reducing production costs without sacrificing garment quality is a priority in apparel manufacturing (Orzada, B. T., 2001). Moreover, Pattern-making technique is a very complex process involving the nonlinear deformation of a 3D surface (garment) to the corresponding 2D pattern (Yang et al, 2007). In addition to human body features, clothes have their own feature points, feature curves, and feature lines (Tsai and Fang, 2003).

This demonstrates how much it is important to improve patternmaking methods used to fit the body more efficiently and effectively, while reducing the time needed for the prototype process.

Objectives

- Studying the current methods and practices used in the sample department for prototypes production.
- Comparison of the current used methods for prototype production and the suggested one.
- Improve the current methods and practices used, to achieve better fitting of prototypes and shorten the process.

Hypothesis

- There are significant differences between the times required for making prototype's patterns using current and suggested methods.
- There are significant differences between the fit goodness of the prototypes made with current and suggested methods.

Methodology

For the development of this research, a number of five Egyptian small and medium apparel factories were investigated for their current prototype development methods, initial field observations were made within each factory, and the results were improved by the participation of the corresponding prototype employee in each factory. The factories were selected in random from the Egyptian women small and medium manufactures specialized in trousers production, the small and medium enterprises (SMEs) is a promising sector of the industry in most of developing countries, moreover, this sector is known for its lake for trained personnel. The points discussed with the pattern makers were mainly about their prototype development practices, table (1) below shows the observations' results and discussed points.

Table (1) field observations' results:

	Factory (A)	Factory (B)	Factory (C)	Factory (D)	Factory (D)
design source	Magazines	Magazines/ Competitors	Competitors	Magazines	Own designer
Pattern acquiring source	Rub-off	Basic blocks	Rub-off and Basic blocks	Very basic blocks	Full set of basic blocks
Unified size-system	2/5	2/5	2/5	2/5	4/5
pattern complication	3/5	3/5	2/5	3/5	4/5
Prototype repetition	6 times	4 times	5 times	4 times	3 times
Fitting and appearance	2/5	6/10	2/5	3/5	7/10
Sew-ability	2/5	4/5	2/5	3/5	3/5
CAD implementation	No	yes	No	No	yes

It is obvious form the field observation that most of factories investigated do not design their own apparel collections, they usually reproduce garments already known for their success in the market, the prototype pattern development relay on the sample garment when it's available, in this scenario, the pattern maker measures the garment's dimension and draw the pattern accordingly.

a prototype from a magazine or a photograph, in this situation the pattern maker will use his own basic blocks to develop the prototype pattern.

Results and discussion

A field observation was made to investigate the current prototypes developing method within the participated factories, the field observation results supported the interview results, both resulted was the analysed, simplified and illustrated as shown in (*figure 1*), this model consist of six steps. Started by the need for a new prototype, followed by choosing the appropriate pattern making method, the third step is the pattern development followed by fabric cutting, the fourth step is the sewing. During the sewing step, the machinist feedback is discussed. If this feedback is accepted, the pattern maker apply it in combination with possible alteration and modification, thus leading to a new start of the process. The prototype is then tested for fitting, once both fitting and appearance are accepted, the final pattern is developed for the mass production, otherwise the required modifications are applied and the prototype process is started over.

Investigating the Egyptian manufacturers' methods of prototype development, show that it is not suitable for the modern industry for these reasons:

1. Produces few and limited number of new products and creations, counterfeiting other manufacturers and retailers goods thus results in limited customers choices.

2. This prototyping model is limited in its capabilities of developing unusual cuts and styles, in addition to complicated fashion features like fullness of different types.
3. Many and critical modifications are needed during the prototype and mass production sewing, for example the seam allowance corners usually is not done the right way resulting in extra unneeded or shortage of fabric, moreover, using a basic blocks with included seam allowance, dos not ensure equality of matched sewing lines lengths. Such inaccurate details results in poor finishes of the prototypes and mass production as well.
4. Poor fitting of the final prototype, and Inaccurate prototype measurements, even after too much repetition of the prototyping process,
5. Not unified size system for all produced garments, results in too many variations of garments' sizes even within the same manufacturers' garments.
6. Provide no base for further development of the prototyping system and pattern development within company over the long term.

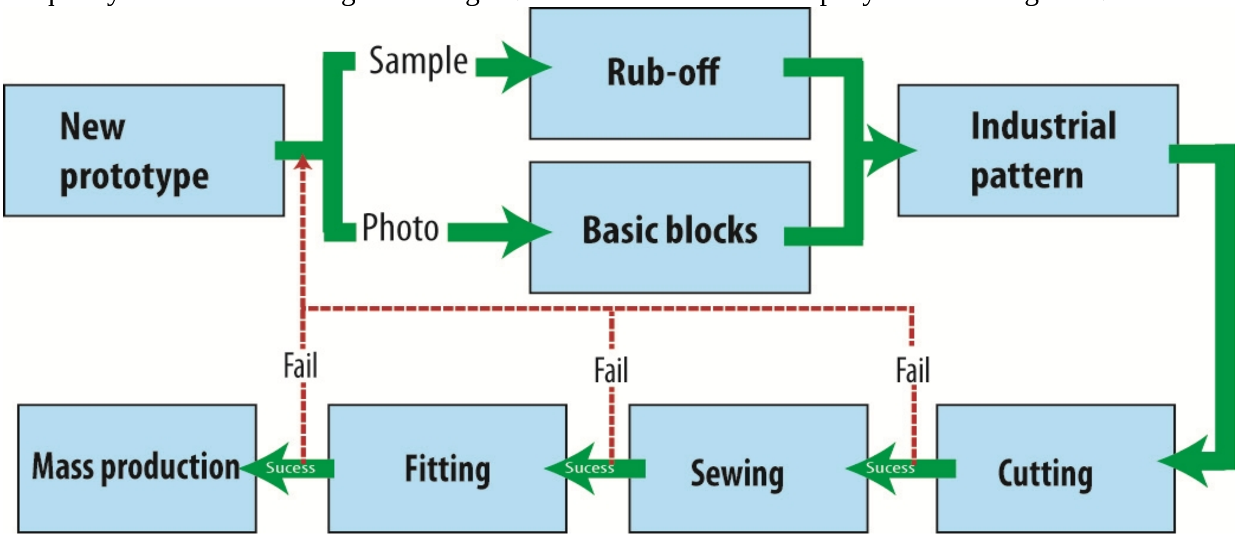

Figure (1) the current prototype developing practises

Results and discussion

A model of the current prototypes developing method in the Egyptian factories was illustrated after investigation (*figure 1*), this model consist of six steps. Started by the need for a new prototype, followed by choosing the appropriate pattern making method, the third step is the pattern development followed by fabric cutting, the fourth step is the sewing. During the sewing step, the machinist feedback is discussed. If this feedback is accepted, the pattern maker apply it in combination with possible alteration and modification, thus leading to a new start of the process. The prototype is then tested for fitting, once both fitting and appearance are accepted, the final pattern is developed for the mass production, otherwise the required modifications are applied and the prototype process is started over.

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A new suggested model for prototype development was developed and explained to corresponding prototype employee in each factory, this model is intended to improve the current methods used in industry, it was built upon it with the help of literature review and research's own experience in the industry, it consist mainly of four steps:

1. Basic blocks construction,
2. Design analyses and secondary blocks (sloper) development,
3. Cutting and sewing, and
4. Fitting.

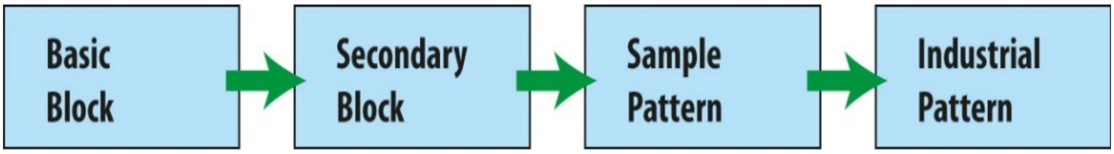

Figure (2) main stages of pattern making process

1. Basic blocks construction

The task of the pattern-makers is to transfer 3D body shape into 2D pattern pieces taking into account physical and fit-related design features (Hlaing et al, 2013). Pattern construction is considered as the first step in establishing the dimensions of the garment (Gill, 2011). A set of basic blocks is mandatory for every apparel manufacturers, a basic block is the fundamental base which then every pattern piece is drawn upon, manufacturers keep a set of basic blocks which are a plain, flat, outlined shapes that closely represent the respective parts of the human figure.

Secondary pattern pieces are those basic blocks that have been refined to produce specific style shape but are adaptable for further modification through the addition of more fashion details, this secondary blocks are updated yearly to reflect current style and sizing systems. When a trend starts to have an underlying structure that can be identified as being a foundation for many other styles, a suitable set of blocks should be made, so that the style changes can be made easily without having to start from scratch every time (Stott, 2012). Figure (2) shows this steps which are then followed by prototypes and industrial patterns development.

2. Design analyses

The job of a pattern maker is to interpret the fashion designer's illustration into sample pattern pieces and draft them out. Garment design is often traditionally based on the designer's visualizations, in cooperation with experienced pattern-makers and tailors, and the combined knowledge and experience in various fields to realize the designer's perceptions (Fang et al, 2008). A Designer/Pattern makers or Creative Pattern Cutter will be working at the innovation stage at the beginning of the design and be more concerned with styling and the shape of a pattern (Stott, 2012).

The pattern maker then works out a garment pattern based on the sketch for trial production several times, and thus a usable planar sloper could be constructed (Fang et al, 2008). This step requires analysis of the design sketch to classify appropriately into the correct garment type, number of pattern sections, identifying the fashion features, and finally determine its dimensions and locations. The skill and experience of the designer plays an important role in achieving the desired product of good fit and high quality (Hlaing et al, 2013). Final sample patterns' should contain information such as seam and hem allowances, grainline, size, balance marks, placement for buttons, buttonholes, pockets and all other necessary information for fabric cutter and sewing machinist.

3. Cutting and sewing:

When the pattern is finished, the pattern pieces are then cut and sewn together to obtain a prototype of the fashion design, If the cloth has been cut well and with all of the notches included, the machinist should be able to sew it together. If the sample mechanist identifies any improvements, the pattern maker should apply it; improvements can be pattern adjustments, a need for special machines or machinery, different ease allowance and/or special seam allowance. After cutting and sewing procedures, an iterative process is undertaken until the appropriate fit is achieved (Bond, 2008).

Once a sample garment is made and approved for manufacture, there is a series of checks before production can begin. It is the Garment Technologist's job to ensure that these have been done (Stott, 2012).

4. Fitting

The fitting of a garment is determined -to a great extent- during the prototyping stage, both the aesthetic and functional characteristics of a garment are influenced by the fit of the garment on the body, apparel which fits provides a neat and smooth appearance, and will also allow maximum comfort and mobility for the wearer. While there are many aspects to good fit, it is essential that the flat, two-dimensional pattern used to make the garment accurately represent the three-dimensional form of the body.

This four steps sequence seems to be logic, however a more detailed model is required, with better and specified relation between each step. The suggested model consist of eight stages, which are; creating basic blocks, secondary blocks, sample pattern, cutting, sewing, fitting evaluation, industrial pattern making and mass production.

Figure (3) shows the suggested model with all required steps and relations between each of them. According to the suggested system, the fitting problems are considered and corresponding modifications are made to the basic blocks, this feedback would improve garment fitting over the long run. Moreover, minor corrections needed during the cutting and sewing stage can be applied to the prototype pattern without the need to restart the whole process.

The fail of cutting stage is a main problem of the prototyping process, however for the purpose of the research it was omitted, focusing on the pattern and fitting problems. The overall speed and accuracy of the prototyping process are supposed to be improved.

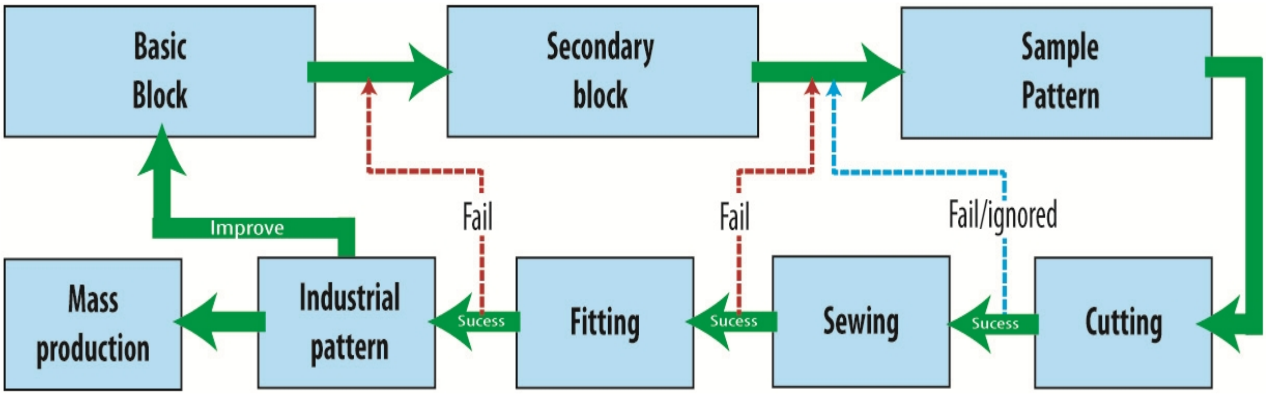

Figure (3) the suggested prototype developing method (Each process' errors fixed internally)

For the purpose of testing this suggested model, a number of two basic and almost similar trousers' designs were made. The prototyping department in each factory was asked to develop a prototype for those two designs following their current methods, after that the suggested methods and system was explained to the pattern maker in each factory, and they were asked once more to develop prototypes for the two design following the suggested system. This two designs are for two basic trousers, the first design is a basic two-pocket trouser, with overstitches on the pocket edge, normal front zipper and a default belt. The second trousers is very similar to the first one, with two pockets in the back side instead of the front ones, the two designs were chosen similar for data reliability purpose, *figures (4) and (5)* show the two designs with corresponding information related to each of them. Times for each stage of the prototype process were measured and compared before and after applying the new system, the prototyping times were summed up for both designs, while being produced in the five factories participated, for each design production times were recorded while using the current methods and while using the suggested system as well. Figure (5) shows the times required for the prototype production for each design before and after applying the suggested system.

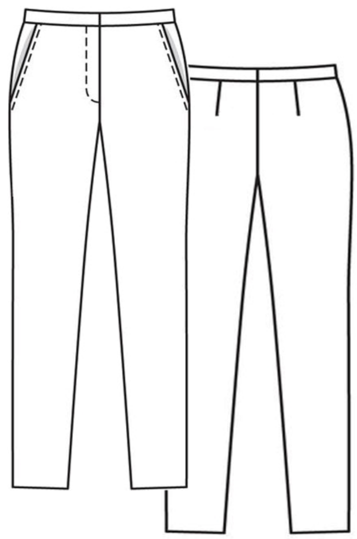

Figure (4), the first design

Pattern size: 40,

Fabric:

- plain weave | 100% cotton
- 100% cotton | 180g/m^2

Machinery:

- Single needle, for the pockets, hems, dart and belt sewing.
- Overlock stitch with three threads for side seams.
- Overlock stitch with five threads for inseams.

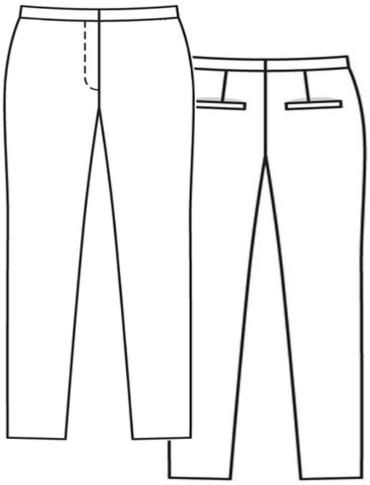

Figure (5), the second design

Pattern size: 40,

Fabric:

- plain weave
- 100% cotton
- 100% cotton
- 180g/m^2

Machinery:

- Single needle, for the pockets, hems, dart and belt sewing.
- Overlock stitch with three threads for side seams.
- Overlock stitch with five threads for inseams.

The diagram in figures 6, 7 shows each prototype production time before (blue) and after (red) applying the suggested system, it's obvious for the diagram that times required for prototype development were shorten after applying the suggested system.

Besides measuring prototyping times, evaluation of the produced prototypes' fit was run using the five fit principles, a standard framework for assessing fit was developed based on the five principles of fit: ease, line, grain, balance, and set. According to those principles four persons were asked to evaluate each prototype, three of the four persons were chosen from marketing stuff, QC and production personnel in each factory, in addition to the researcher, all of them were asked to evaluate the goodness of the four prototypes' fit on a scale of 10 degrees.

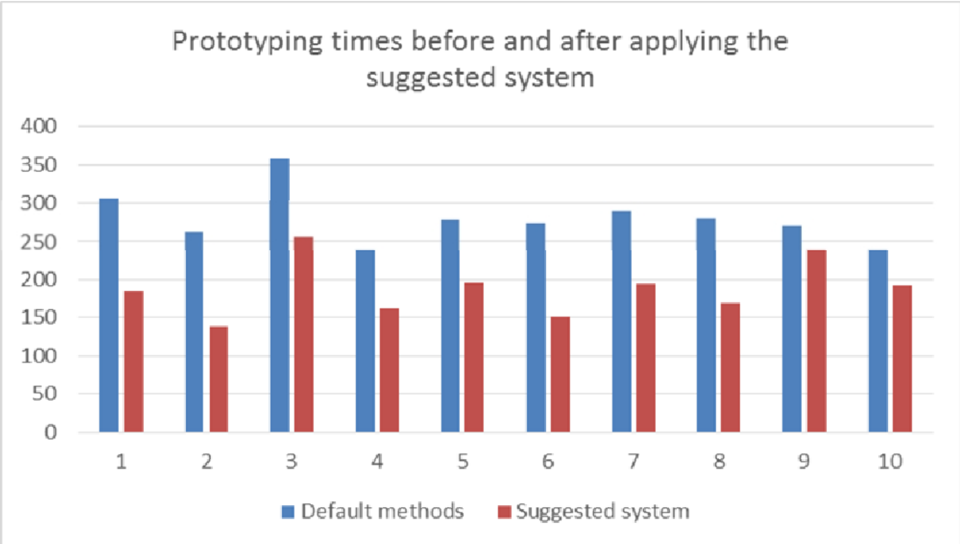

Figure (6), Prototyping times before and after applying the suggested system

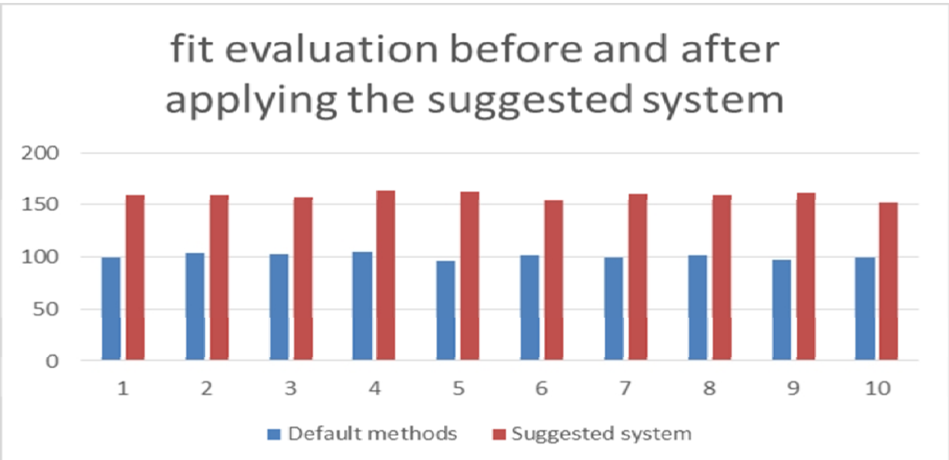

Figure (7), fit evaluation before and after applying the suggested system

Each prototype was evaluated by four persons, for the five principles of fitting, resulted in 20 observations for each prototype. Table (3), below, shows the production times and fit evaluation results combined with the standard deviation (SD) for each prototype fit evaluation.

Table (2) times and fit goodness before and after applying new methods:

	Prototypes	Production time sum	Fit degree Mean	Fit degree SD
Prototypes before	Factory (A) Prototype1	305	5	0.84
	Factory (A) Prototype2	262	5.2	0.75
	Factory (B) Prototype1	358	5.15	0.79
	Factory (B) Prototype2	239	5.25	0.77
	Factory (C) Prototype1	279	4.8	0.81
	Factory (C) Prototype2	273	5.1	0.77
	Factory (D) Prototype1	289	5	0.77
	Factory (D) Prototype2	280	5.1	0.70
	Factory (E) Prototype1	270	4.85	0.79
	Factory (E) Prototype2	239	5	0.77
Prototypes before	Factory (A) Prototype1	184	8	0.84
	Factory (A) Prototype2	139	8	0.71
	Factory (B) Prototype1	256	7.85	0.85
	Factory (B) Prototype2	162	8.2	0.81
	Factory (C) Prototype1	196	8.15	0.57
	Factory (C) Prototype2	152	7.7	0.84
	Factory (D) Prototype1	194	8.05	0.86
	Factory (D) Prototype2	168	8	0.89
	Factory (E) Prototype1	239	8.1	0.89
	Factory (E) Prototype2	193	7.6	0.80

To compare the variances between each group of data, the *F-distribution* test were run between each groups. Table (3) shows the results of both tests before and after applying the suggested methods. For the Prototype production time the *F-distribution* test result was (0.88), which is larger than the F Critical value (0.31). Therefore, the null hypothesis were rejected. The null hypothesis assumes no difference between each group of data, therefore the *F-distribution* test results verified that the two populations are unequal.

For the Prototype fit goodness assessment the *F-distribution* test result was (0.56), which is larger than the F Critical value (0.31). Therefore, the null hypothesis were rejected. The null hypothesis assumes no difference between each group of data, therefore the *F-distribution* test results verified that the two populations are unequal.

Table (3), the F-distribution test and t-test results:

		Prototype production time	Prototype fit goodness
		Observations (10)	Observations (10)
F-Test	F	0.88	0.56
	F Critical	0.31	0.31
t-test	t Stat	8.97	38
	t Critical	1.83	1.74

The results of the f- *distribution* test indicates that the variances of the time required for prototype development before and after applying the new methods are unequal, moreover it indicates that the variances of the fit goodness of prototypes developed before and after applying the new methods are unequal too. The *f-distribution* test verified that the two populations are unequal, however, for a deeper analyses of the data, the t-test was run between each group, the purpose of the t-test is to discover which method resulted in better times and fit goodness of prototypes.

The t-test were run between each group of data, first and second fit evaluations and time measurements were compared. (Table 3) shows that there were significant differences between the first and second fit evaluations. For the prototype production time the t-tests result was (8.97), which is larger than the t-test critical value (1.83). Therefore, the null hypothesis were rejected. Indicating there is a significant difference in use of the two prototype production methods.

For the prototype fit goodness assessment the t-tests result was (38), which is larger than the t-test

Critical value (1.74). Therefore, the null hypothesis were rejected. Indicating there is a significant difference in use of the two prototype production methods.

Conclusion

The quality evaluation of apparel products depends on aesthetic values, like appearance and fit, both of those two values are formed to a great extent during the prototype development process, which like all other production steps requires time and efforts in order to fulfil designers and retailer's needs. Moreover, the modern market competitive pressure requires reduction of time and costs of product development in the clothing industry.

Improving the prototyping and product development process should help the apparel industry enjoying cost-cutting effects. A company does not have to spend money and time repeating the prototyping process to apply too many fixes, moreover, applying this improved systems supposed to help them acquiring success in apparel market which depends heavily on the human aesthetic sense.

This paper is intended to develop a new and improved system for prototype development within the Egyptian industry. A number of five Egyptian small and medium apparel factories were investigated for their current prototype development methods, initial field observations were made within each factory, and the results were improved by the participation of the corresponding prototype employee in each factory. A model of the current prototypes developing method in the Egyptian factories was illustrated after investigation, this model was then analysed. A new suggested model for prototype development was developed, this model was built upon the literature review and research's own experience in the industry.

A number of two prototypes were made in each factory using the current methods, a total number of ten prototypes were made using current methods. after that another ten prototypes were made for the same two designs again using the suggested system, two prototypes in each factory, observations were collected of times required for the twenty prototypes development (ten observations) before and (ten observations) after applying the new system, and the fit goodness of them was evaluated too.

Data analyses included the *f-distribution* test followed by *t-test*, both of the testes indicated a significant difference between the observation before and after applying the new system. The t-test were run between each group of data, the t-test results shows a significant differences between the first and second fit evaluations. For the prototype production time the t-tests result was (8.97), indicating there is a significant difference in use of the two prototype production methods. For the prototype fit goodness assessment the t-tests result was (38), indicating there is a significant difference in use of the two prototype production methods. The new prototype development system helped shortening the times required for the process, in addition to improving the fit goodness of the prototypes and the final products afterwards.

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