Developing a zero-waste pattern drafting method suitable for mass production

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ABSTRACT – REZUMAT

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The fashion industry is well known for being one of the most polluting industries worldwide, and its contribution to textile waste and apparel consumption has grown in significance over the years. The development and integration of zero-waste patterns in designing sustainable apparel represent a promising approach that supports reducing pre-consumer textile waste and optimizing fabric consumption. Moreover, it encourages society to step into a new era of the garment industry, by shifting the regular way in which consumers are currently perceiving apparel items: a trend, rather than a need – based on a survey conducted in 2023 by the author. The study focuses on the design principles and techniques of zero-waste patterns and their impact on fabric utilization. For this study, the patterns have been digitally drafted and nested, testing the requirements given by the chosen fabric and waste minimization. To acquire a specific image of the result, consisting of the garment item, has been virtually simulated. This method of obtaining the product's prototype aims to highlight and encourage the paradigm shift concerning digitalization that needs to take place within the manufacturing industry. The results of the study demonstrate that zero-waste patterns can reduce fabric consumption and significantly reduce pre-consumer waste, but their drafting methods are highly related to the design process and the chosen fabric's characteristics, such as usable with or print artwork.

Keywords: *apparel industry, pre-consumer fabric waste, sewing patterns, size set, sustainability*

Dezvoltarea unei metode de proiectare a tiparelor zero-waste aplicată pentru producția în masă

Industria modei este renumită ca fiind una dintre cele mai poluante industrii la nivel mondial, contribuind în mod semnificativ, în ultimii ani, la producerea deșeurilor textile, precum și la dezvoltarea consumului de îmbrăcăminte. Dezvoltarea și integrarea tiparelor zero-waste în procesul de proiectare a articolelor vestimentare sustenabile reprezintă o abordare promițătoare, ce susține reducerea deșeurilor textile pre-consum, precum și optimizarea consumului de material textil. În plus, încurajează tranziția spre o nouă eră în cadrul acestui domeniu, prin modificarea modului prin care consumatorii percep la momentul actual produsele vestimentare: drept o modă, și nu o necesitate – bazat pe un sondaj de opinie efectuat în anul 2023 de către autor. Cercetarea realizată se concentrează asupra principiilor de design, precum și a tehnicilor de proiectare a tiparelor zero-waste, și în consecință asupra impactului pe care acestea îl au asupra consumului de material textil. Pentru acest studiu, tiparele au fost proiectate și încadrate digital, ținând cont atât de cerințele impuse de material, cât și de minimizarea deșeurilor textile. Cu scopul obținerii unei imagini reprezentative a produsului vestimentar analizat, a fost realizat prototipul virtual al acestuia. Prin această metodă s-a urmărit evidențierea și încurajarea schimbării de paradigmă în ceea ce privește digitalizarea proceselor din cadrul acestei ramuri industriale. Rezultatele studiului demonstrează faptul că tiparele zero-waste pot reduce consumul de material textil, minimizând în mod semnificativ cantitatea de deșeu textil pre-consum, însă metodele de proiectare a acestora sunt în strânsă legătură cu caracteristicile materialului ales, precum lățimea utilă sau direcția imprimeului.

Cuvinte-cheie: *industria produselor de îmbrăcăminte, deșeu textil pre-consum, tipare, gamă de mărimi, sustenabilitate*

INTRODUCTION

The fashion industry has become well known for its glamour and ability to express the wearer's social status, preferences, and personality, in a way that does not imply using words. Through clothing items, people can adorn themselves, which also plays an important role in shielding one's body from outside threats. Apart from the representative assets that the fashion industry possesses, there is an opaque side to it, that goes hand in hand and shares simultaneous progress with the former aspect previously presented, given the increased consumption of apparel items [1]. Thus, the attention can be directed toward the negative side of the fashion industry. Even though its effects are not as visible or obvious to the naked eye of the regular consumer, they are present and ever-growing [2, 3]. The fashion industry is known for its high fabric consumption and pre- or post-consumer textile waste that's generated throughout the product's life cycle. Traditional garment production methods often result in the production of pre-consumer textile waste due to the inefficient use of fabric. Oftentimes, the unused fabric scraps are destroyed, either by incineration or landfill disposal. Both methods have a major impact on the environment (air, water, and land pollution), thus directly threatening human health. Considering the production process of textile fabric, as well as the polluting implications that are generated during the making process, one can appreciate the need to develop and adopt systems that capitalize on these textile resources. The generation of material losses during tailoring is a predictable and imminent factor that takes shape in the pattern design process [4].

Since the amount of textile material included in the composition of an article of clothing exceeds 50% of the total garment item, it is particularly important to develop practices and methods that ensure the most efficient utilization of the fabric.

Due to the current socio-cultural diversity, clothing is presented in a very wide range of shapes, sizes, and shades, designed to meet all the demands and needs addressed by consumers.

The apparel market has seen growth over the years [4], and it is expected to grow even further, in the upcoming years [5, 6], with a remarkable global rate of 63% by 2030 [7]. Those increasing tendencies include generating significant amounts of pre-consumer fabric waste, contributing to the expanding climate crisis [8]. On the European level, the policy of the 3R, which encourages the reduction, re-usage, and recycling of solid waste, was first integrated and promoted within the Waste Framework Directive (WFD, 2008/98/EC), in 2008.

Reusing and recycling are two processes on their own, that require resources needed to reintegrate solid waste back into the life cycle. Given the ongoing war in Ukraine, the prices for energy, transport, and raw materials have increased [9], thus emphasizing the prevention principle as being the most preferred outcome.

Within manufacturing factories, the pre-consumer waste mostly consists of leftover fabric or fabric scraps generated during the cutting process. If collected separately, those are then either incinerated, reused, or recycled, based on the profile of the collectors. Thus, the result can be translated as either air pollution or resource consumption. The resolution which enables the minimization and prevention of solid pre-consumer textile waste generation consists of using geometrical sewing patterns, which ensure the complete usage of the fabric, within the given usable width of the textile material. Such patterns caught the public eye in the last decade, despite being a popular technique of tailoring back in ancient times [10]. Recent studies have analysed the process of engineering clothing items, by using zero waste patterns (ZWP), developing new approaches as well as identifying several limits [11, 12].

Considering the complexity of drafting a ZWP set, the process of developing a technique that can be applied in the apparel industry may seem problematic [13]. In some cases, the seam allowances can be altered, to ensure the coverage capacity of the pattern's cutting perimeter [14], whereas, in other given circumstances, the unused fabric pieces can be attributed to aesthetic or practical value, by integrating them into the garment item as pockets or other decorative accessories [15]. It is important to mention the mass production that can be obtained, by using a ZWP set, for making multiple production units. The method implies generating different pattern sets, following the size range for which the units are produced [16].

METHODOLOGY

The development of the ZWP drafting technique is based on drafting the initial set of classic patterns, which represent the base, shape, and dimensional-wise, on which the ZWP will be shaped. Nonetheless, the existence of a classic pattern set (CPS) will help in obtaining a concluding comparison regarding fabric usage and marker efficiency between the two types of patterns. The CPS has been obtained by shaping the base patterns following the design particularities of the chosen style.

The patterns have been drafted and developed using the Gemini Pattern Editor (GPE) software, and the layplans have been generated using the Gemini Nest Expert (GNE) system, which automatically generates the marker efficiency, as well as the fabric usage. The garment item has been virtually generated, using CLO 3D.

This research is based on reducing the pre-consumer textile waste that may be generated during cutting, by recovering potential scrap fabric and identifying a way through which it can be integrated into the value chain. The object of this study consists in optimizing fabric consumption, by drafting new pattern pieces. The starting point is the layplan initially generated to nest the existing classical pattern pieces for a women's dress item. The areas of unused fabric have been repurposed, to create a new set of patterns. Thus, a second apparel item (blouse) has been created.

The study employs practical research, which began with the extraction of the most important body measurements, provided by a physical avatar (mannequin). The measurements collected (table 1) correspond to the size S range, based on the international sizing system (table 2). The measurements were used to dimension the virtual avatar, in accordance with the physical one (figure 1), and also served in drafting the base patterns, as well as the CPS for the initial dress.

Table 1

MEASUREMENTS COLLECTED FROM THE PHYSICAL MANNEQUIN

Measurement	Value (cm)
Chest perimeter	85
Waist perimeter	68
Hip perimeter	92

Before proceeding with the pattern drafting, the first step is implied opting for the fabric from which the

Table 2

INTERNATIONAL SIZING SYSTEM CHART [17]			
Chest perimeter (cm)	Waist perimeter (cm)	Hip perimeter (cm)	International System
74	58	80	XXS
74-77	58-61	80-84	XS
78-81	62-64	85-89	XS
82-85	**65-68**	**90-94**	**S**
86-89	69-72	95-97	S
90-93	73-77	98-101	M
94-97	78-81	102-104	M
98-102	82-25	105-108	L
103-107	86-90	109-112	L
108-113	91-85	113-116	XL
114-119	96-102	117-121	XL
120-125	103-108	123-128	XXL
126-131	109-114	129-134	XXL

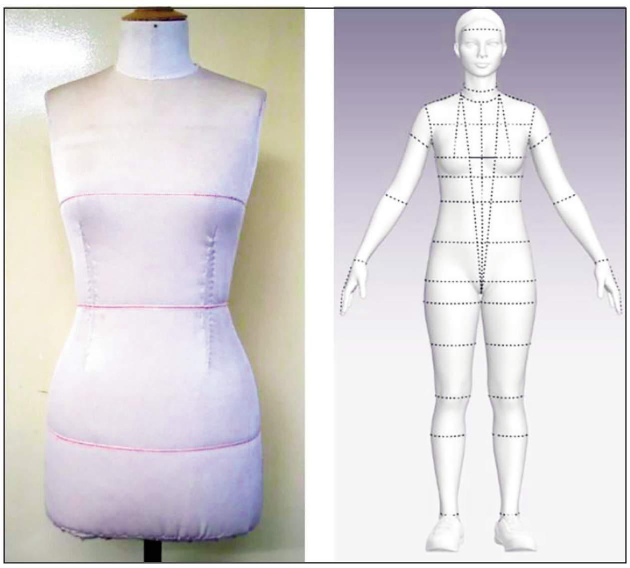

Fig. 1. The physical mannequin (left) and the virtual avatar (right)

clothing items will be manufactured. For this particular research, the velvet fabric has been chosen, because its structural surface requires the pattern pieces to be placed in one direction only. The width of this fabric is 141 cm.

Once the CPS for the dress item have been drafted, the initial layplan has been generated. By placing the pattern pieces for the initial garment, it was able to identify the fabric waste areas that could potentially be generated (hatched areas depicted in figure 2).

To make the best use of the potential waste fabric, a pattern library has been established, containing several CPS for the most common women's garment styles (mainly consisting of front, back and sleeve panels). Thus, a series of classical patterns sets previously drafted have been collected (figure 3). These will serve as a starting point based on which new ZWP will be developed.

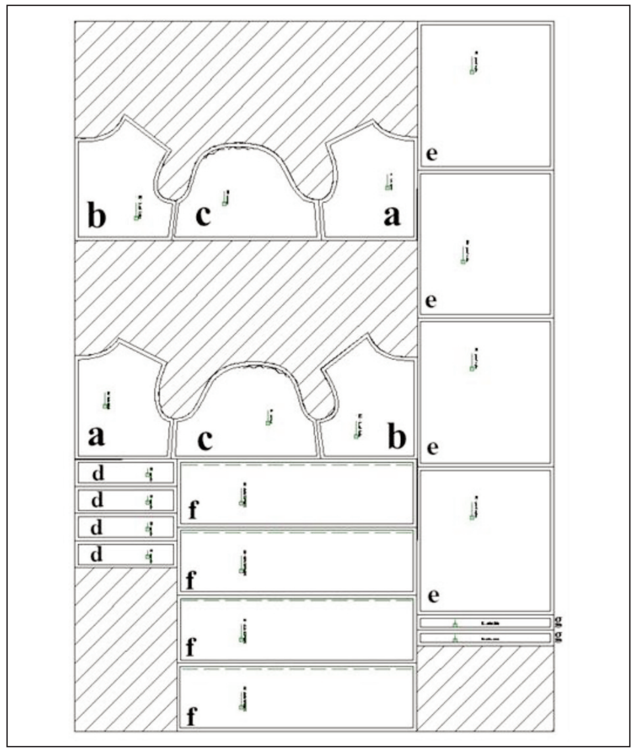

Fig. 2. Placing the dress CPS within the simulated fabric perimeter: *a* – front bodice; *b* – back bodice; *c* – sleeve; *d* – cuff; *e* – skirt panels; *f* – hem frill panels; *g* – neckline facings

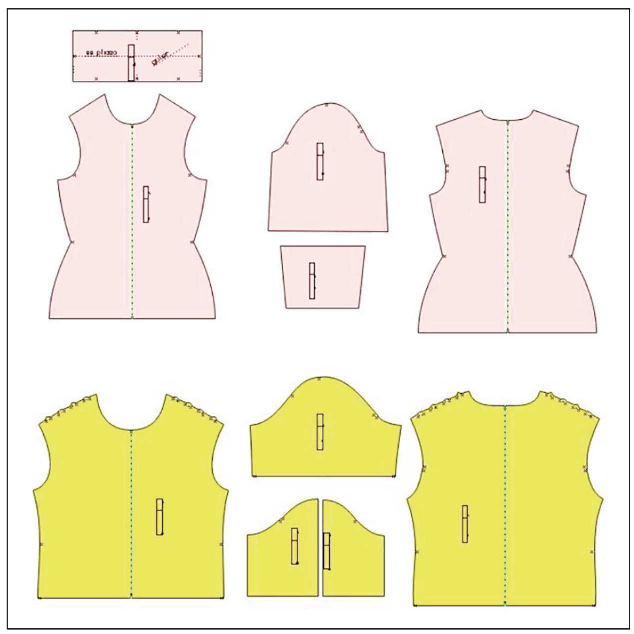

Fig. 3. Classical pattern library: example of two distinct women's blouse styles

The cutting surface for each pattern piece has been measured, using the Surface Measure option provided by the GPE software. The same method has been applied to the available unused fabric pieces in the marker previously simulated. The purpose of this operation is to facilitate the process of assimilating the available fabric surface to a feasible pattern piece. This is possible by using the format conditioning functions, which are available in spreadsheet software.

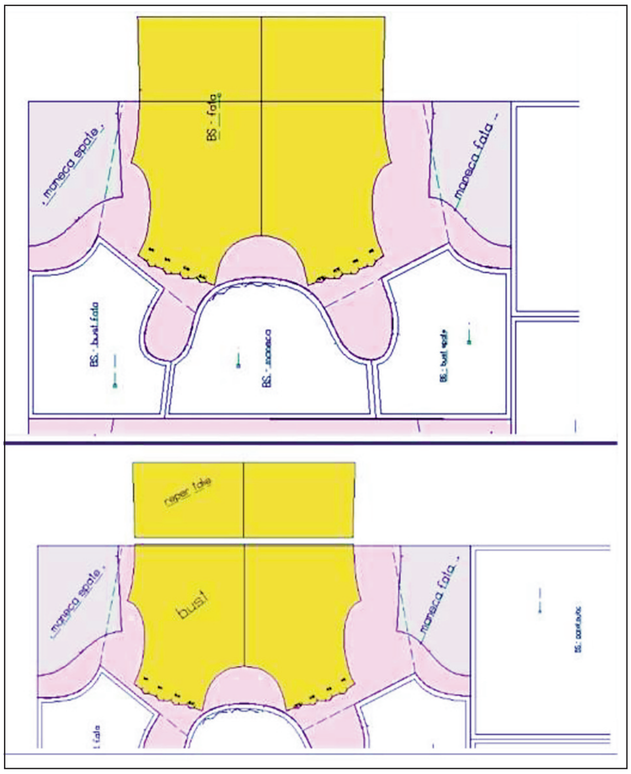

Fig. 4. Identifying the geometric similarity between the available surface and the potential surface – this highlights the need for pattern transverse sectioning around the waistline

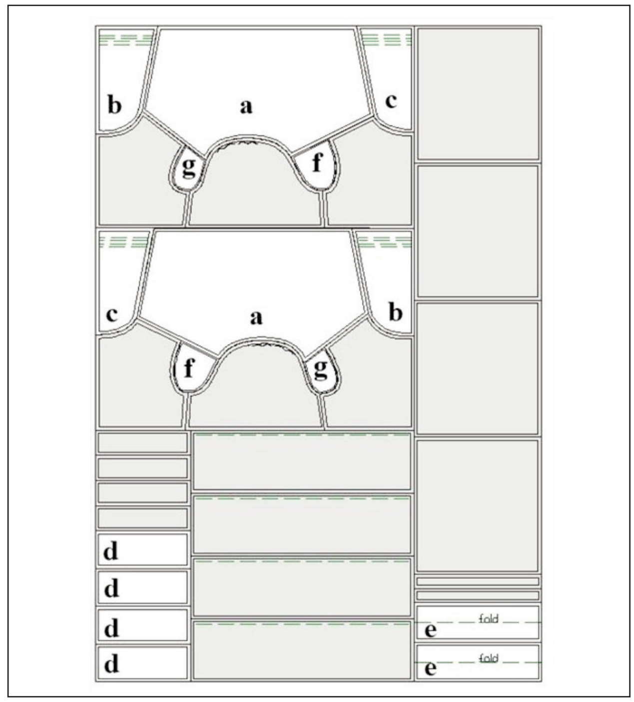

Fig. 5. Unused area converted into ZWP: *a* – front/back bodice; *b* – front sleeve panel; *c*–back sleeve panel; *d* – waistline panels (with centre front and centre back seam); *e* – collar panels (front and back); *f* – front sleeve head reinforcement; *g* – back sleeve head reinforcement

After analysing the shape-wise possibilities provided by the available fabric surface, the shape of a bodice was straightforwardly identified. Thus, the area has been sectioned (as depicted in figure 4), to define the shape that has been identified.

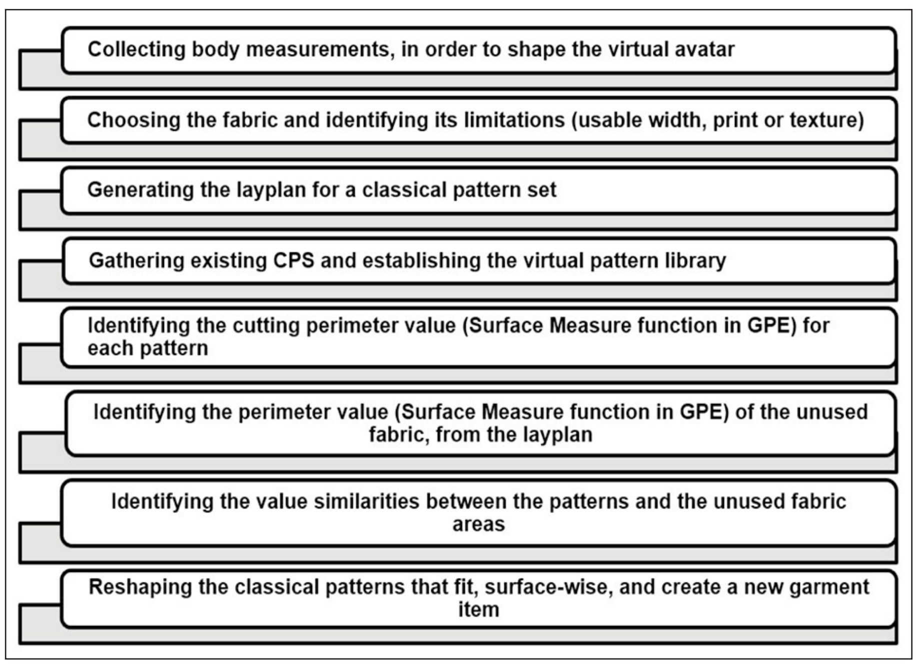

Fig. 6. The stages for developing the ZWP

It's worth mentioning the fact that this process of altering the classical pattern pieces, to generate ZWP is, in its essence, a design process, in the sense that during this phase, the style features are being established, based on the restrictions encountered. Using the surface comparison method previously established, the possible pieces that fit within the given area were effortlessly identified (figure 5).

For a clearer comprehension, the steps that have been taken within the design process have been summarized, as depicted below in figure 6.

The limitations that have been encountered during the design process were given by the fact that velvet is a pile fabric, and thus its surface has a certain one-direction orientation, mostly visible when a source of light is directly pointed on the fabric [18]. Thus characteristic has a great effect on the final product's aesthetic value, and for that instance, the pattern sets had to be placed by following only one specific orientation. Apart from that, the fabric width is a general restriction regarding the process of drafting the ZWP, because its value determines the width of the layplan.

RESULTS

Fabric rating and marker efficiency

Once the pattern modelling, the final marker has been made, using the GNE software. The program can provide the marker efficiency [%], as well as the length of the final layplan in cm. Through this, it was possible to test the conformity of the patterns to the initially imposed restrictions, given by the fabric and the ZW principle itself. Thus, the pieces were nested on a 141 cm usable width, with a 99.48% efficiency (figure 7). Those values confirm that the ZWP meets the initial requirements. The fabric rating for the two garment items is 2.09 m (without technological losses). In comparison, the fabric rating for the initial clothing item (using the CPS) was 1.6 m, with an 84.5% marker efficiency.

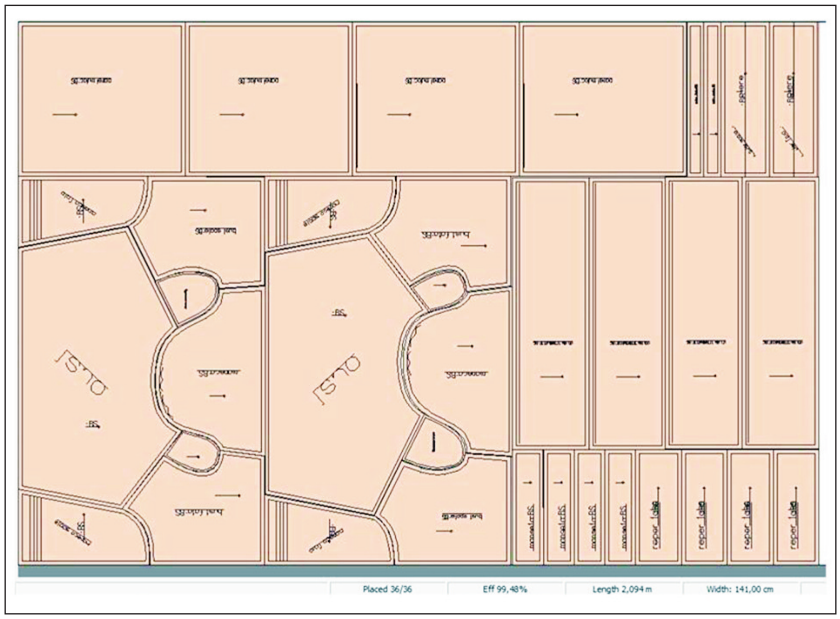

Fig. 7. ZW marker: 99.48% efficiency, 2.09 m rating and 141 cm width

The virtual prototype

The new pattern pieces have been assembled within the virtual space, in order to obtain a general first image of the product. Given the loose and asymmetrical cut of the patterns, the garment has been fitted on the avatar by using shirring as a modelling technique. This method not only added value to the final product but also allowed for a dimensional reshaping of the main measurement points. At this point, the initial body measurements have been used as a guideline (figure 8).

Fig. 8. The virtual prototype for the blouse: raw aspect (left) and finished (right)

Nonetheless, it is worth emphasising the fact that by using virtual prototyping, instead of physical sampling, the benefits consist of reducing the usage of electricity (considering the plotter, sewing machines and ironing), as well as paper (used for printing the patterns). Also, trial and testing the pattern sets in a virtual environment prevents the usage of fabric, and also inhibits the manufacturing of pilot prototypes.

Fig. 9. ZW blouse fitted on a size S avatar (left) and size XL avatar (right)

Mass production opportunities

Drafting ZWP by exploiting the unused fabric surface as a guideline, and with the help of a pattern library, has proven to be efficient in diminishing the time needed to draft patterns from scratch. Nonetheless, since the patterns are drafted on the cut line, it creates a wider range of technological possibilities within the manufacturing process, because the seam allowances are lastly traced as a contour offset at a given distance. Depending on the assembling, the seam allowance values can vary, without affecting the cutting perimeter of the ZWP. The ZWP set obtained as a result of the exploitation of the unused fabric surface can be used in mass production

– albeit not graded, the product dimensions on the main points can be adapted from size to size by altering the gathering dimensions (shoulder line, cuff, waistline, and neckline).

The blouse can be classified as a one-size product, which can be altered from a dimensional perspective on the neckline and waistline, by adjusting the gathering dimensions. Given the loose fit, is not mandatory for the shoulder line, sleeve length, or bust line to present a significant increase from one size to another. The product fit for the extreme sizes of the range is depicted in figure 9.

The results of the study demonstrate that ZWP, not only can significantly reduce fabric consumption but also sustain the achievement of a high maker efficiency, which translates itself as zero pre-consumer textile waste generated during cutting.

CONCLUSIONS

By analysing the framework of the research, it can be concluded that drafting ZWP represents a design process of its own, during which, the pattern maker has to adopt the designer and technician roles as well. The framework of the drafting process has been analysed

These three aspects intertwine and have no limited time correspondence throughout the process, as they are simultaneously present within the procedure. As an example, from a pattern-maker perspective, the pattern pieces must be joined perfectly on the assembling lines, whereas from a technician's point of view, the seam allowance values must correspond to the types of finishing that suit the chosen fabric. Lastly, the designer is rather interested in an aesthetically pleasing product. Therefore, it is clear to estimate a gap in communication between at least two of the mentioned characters. To ensure an efficient and optimal drafting process, these three aspects should all be present within the thinking process of the engineer.

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