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Sustainable Children's wear with Zero-Waste Grading Design in the Clothing Industry

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ABSTRACT

This research aims to focus on the zero-waste clothing design of childrenswear to address sustainability in the children's clothing market. By reducing variables from fabric waste, the zero-waste idea may be optimized throughout the design process. Furthermore, the development of technology has revolutionized the way people conduct their daily lives worldwide. Hence, the objective of this study is to suggest a digital zero-waste childrenswear design in the clothing industry with multiple grading. So, as one of the zero-waste techniques, the Jigsaw Puzzle is used for making patterns and grading techniques in this research. For all the aggregate parts of the entire garment, fabric width dictates the pattern size. The study demonstrated that the multi-digital grading zero-waste technique would be used on mass production to make more profit in the clothing sector. In this regard, the study's conclusions can guide designers, patternmakers, and manufacturers. To make more objective selections and encourage the development of innovative design in zero-waste childrenswear collections. Therefore, the findings could be used in a variety of clothing products to aid in the reduction of environmental pollution and resource depletion issues associated with the clothing industry toward making more profit in the children's market.

Keywords: Childrenswear market; Sustainable fashion; Pattern grading, Zero-waste design.

1. INTRODUCTION

The notion of sustainable design has been entrenched in children's products (Zhang, 2018). Complicated clothing design might lead to visual fatigue. The design of children's clothing should be flexible and straightforward to promote children's aesthetic awareness and focus their health on sustainability (Bezerra et al., 2017). Furthermore, there has been limited research on children's clothing, and fashion features are frequently overlooked. Therefore, it is appropriate to emphasize design as a catalyst for developing the sustainable children's clothing industry. One of the creative strategies in sustainable design is zero-waste pattern creation. Indeed, seamlines play an essential role in forming garments, whether using the zero-waste pattern approach or the traditional way. As a result, reducing seamlines can aid in improving the functionality and other abilities. Other

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pattern designs, such as origami or draping, cannot grade patterns and may only be applied to one piece in free size, so they would not be extended in mass production. To maximize profit, a designer must have the capacity to create and sell locally and globally to meet business goals, which will ultimately convert into national ambitions.

Moreover, the garment industry is rapidly expanding with innovations to keep the fashion business maintained. Tabraz (2017) points out that advancements using computer-aided design (CAD) technologies are required to fulfil market demand in the fashion business. The CAD industry can quickly do the design process. The results can be directly seen in 2D and 3D illustrations that almost resemble a tangible form. Furthermore, Papachristou et al. (2019) showed that CAD could make garment prototypes from ten different clothing design patterns, a big deal in the clothing industry and fashion business. Furthermore, because digital grading and CAD features are critical in this study, the design of zero-waste sustainable clothing may be used in mass production. Indeed, making a zero-waste design in numerous sizes is far more complex or unique than conventional designs and has not been investigated before.

Hence, the study's state-of-the-art is to examine new approaches and creative methods of children's clothing design based on the notion of sustainable qualities, focusing on zero waste techniques using technology in the clothing industry. Therefore, this study will investigate "how can zero-waste sustainable design be utilized and graded in the mass-production of the children's clothing industry and the clothing market?". Consequently, this study suggests a zero-waste childrenswear design by reducing variables from fabric waste to boost the optimization in the design process and use in the children's clothing industry. In this research, the fabrics were utilized to create designs, and no waste was generated. Besides, the study considers the physical and psychological demands of children's clothes. This practice-based study investigates ways to minimize fabric waste via zero-waste pattern cutting to improve outcomes and contribute to the industry and society. Therefore, it can be helpful as a guideline for designers, pattern makers and to encourage the development of innovative design in zero-waste childrenswear collections. Additionally, it would be applicable in a variety of clothing manufacturing to aid in reducing environmental pollution and resource depletion issues associated with the clothing industry toward making a profit and a good image in the children's clothing market.

2. LITERATURE REVIEW

Children's products are designed to meet physical and psychological needs. They should be manufactured according to the actual needs of the children, with new forms and a unique look that attracts children's attention (Köksal, 2007). Children like clothes, but they also want to buy them (Shaharuddin & Jalil,2021). Complicated clothing design might lead to visual fatigue. The design of children's clothing should be flexible and straightforward to promote children's aesthetic awareness (Bezerra et al., 2017). Shaharuddin and Jalil (2021) showed that some of the standards that support children's health are neglected by manufacturers and designers in designing children's clothing.

Children's clothing design needs to be comfortable, convenient, safe. Attention needs to be paid to actual demand, production costs, compliance with the concept of human-oriented design in line with child growth, physical and mental health (Jalil & Shaharuddin, 2019; Zhang, 2018). Hence, the previous researchers investigated and recommended several subjects: (1) Children's clothes between the ages of 2 and 12 shall be without hoods and drawstrings. Therefore, velcro, snap, and button closures can be used on the jacket hoods instead of drawstrings (ASTM F1816-9, Australian Competition and Consumer Commission, 2011). (2) The use of pom-poms, sequins, and beads for children's clothing up to 4 years of age is not recommended. Therefore, screen-printing, embroidery patterns and other simple fabric designs can be a good alternative (ASTM F1816-97). (3) Buttons, for example, should not have sharp edges and should have at least two stitches attached to keep the part flat and secure (European standard EN 14682, 2007). (4) The multifunctional design concept in children's clothing can increase consumption as children grow up quickly (Cunha & Broega, 2009; Jalil & Shaharuddin, 2019). (5) The use of a single fabric can affect the recycling process after use, allowing designers to easily disassemble (Gam et al., 2010). On the other hand, Jalil and Shaharuddin (2019) investigated that a high percentage of fabric and clothing waste is related to fabric waste and children's clothing thrown in the landfill during the manufacturing process. Moreover, there is a lack of research on sustainable techniques in children's clothing manufacturers. The practical, sustainable methods in the children's clothing process only focus on functional design and eco-friendly materials (Cunha & Broega, 2009; Gam et al., 2010; Naz, 2019; Zhang, 2018).

One of the creative strategies in sustainable design is zero-waste pattern design. Reduced seamlines in the zero-waste approach can boost functionality and make it easier to switch to other abilities (Jalil & Hosseini, 2020). Fitting the pieces together with a zero-waste design ensures that no fabric is wasted during the cutting process. Moreover, TI Rissanen (2008) discussed the history and reasons for eliminating waste materials from clothing production and the possible advantages of its methods in establishing zero-waste fashion design. Furthermore, Timo Rissanen and McQuillan (2016) investigate zero-waste design and find a variety of viable techniques for waste elimination. Hence, this article uses Rissanen's Jigsaw Puzzle technique (Timo Rissanen & McQuillan, 2016) to make patterns and grading techniques.

The complete garment pattern is engineered to accommodate the fabric width. Furthermore, grading is well recognized in the clothing manufacturing business as the technique of appropriately raising or lowering a given size pattern section from one size to another while keeping everything faithful to its original shape (Jalil & Hosseini, 2020). However, most sustainable pattern techniques, such as origami or draping, have to be applied to one piece in free size and cannot be used in mass production. According to Bye et al. (2008), traditional industrial grading procedures do not give an excellent fit. Furthermore, Jhanji (2018) noted that pattern grading is connected with complicated mathematics and arduous effort to scale a pattern into multiple sizes when done manually. Computer-aided design (CAD), on the other hand, is a reliable and effective tool in the hands of designers engaged in research, innovation, new product design, and

development (Jhanji, 2018). There are numerous advantages to employing computer-aided design (CAD) methods in the fashion design and patternmaking process, including time-saving and cost-effective solutions to a wide range of challenging tasks (Sayem et al., 2010). CAD-based software allows fast pattern grading adjustments to fit a wide range of products, including complicated size variations. Pattern grading may also be done precisely using the programme to create varied standards or base sizes (Jalil & Hosseini, 2020). Various parts and values can be rated at the same time.

Additionally, the programme has a basic notch and split part grading, angle grading for complicated forms, modification grading for short-term sizes, and variable grading for bigger sizes, particularly useful in the clothing market and business (Jhanji, 2018). Moreover, (Jalil and Hosseini (2020)) showed no more investigation in pattern grading toward sustainability with the utilization of CAD-based software, especially in the children's clothing sector. Hence, the developed zero-waste sustainable designs can be utilized in mass-production since technology, grading concept and CAD features are essential in this study.

3. METHODOLOGY

The research began with "cut and sew" experiments within the traditional fashion system. Four core outfits were constructed for the experimental stage to provide some insights into feasible design options. These prototypes were primarily conceived and created with a zero-waste concept. CLO3D Simulation software, version 6.0.374, was used to create and develop all prototype models to determine the optimal usage of the textiles and print mass-production patterns. Four styles of children's clothing were chosen as more appealing items for purchase in the children's clothing market in 2020 (statistica.com). The design focuses solely on zero-waste patternmaking in children's clothes. In addition to pattern creation and measuring all the elements, the computer-aided design was employed through the utilization of Gemini Pattern Editor software, version 19. The measurement of a children's body is based on the worldwide standard was utilized for clothing measuring in this study as named XS, S and M. For this investigation, clothes were measured using a small size (S) of the worldwide standards. There were two ways to achieve the zero-waste design: moving the inner lines and reorganizing clothing elements in the marker arrangement. Suppose the waste is reduced to zero in stages. In that case, each stage's fabric is calculated, and the waste reduction of each operation is evaluated.

4. EMPIRICAL RESULTS

Figure 1, Figure 2, Figure 3, and Figure 4 show the augmented designs of this study that all fabrics are used to make patterns, and no waste has been achieved. This investigation led to selecting some of the designs found in children's apparel resources for concept generation. When the first design was created, it was done using the traditional patternmaking method (b) in Figures 1, 2, 3 and 4). After that, using Gemini Pattern Nesting, the amount of fabric waste (optimization) was estimated after removing the primary layout's parts. The block designs were then rearranged following the creators'

imaginations. Then, a new structure for the presentation of patterns in the layout was achieved without fabric waste. Afterwards, the pattern grading is completed in different sizes of children's patterns XS and M from base S size, which is done accurately on the software and grade tables for style interpretation ((a) in Figures 1, 2, 3 and 4). Finally, the mock-up of zero-waste children's outfits for each design is simulated ((c) in Figures 1, 2, 3 and 4) separately.

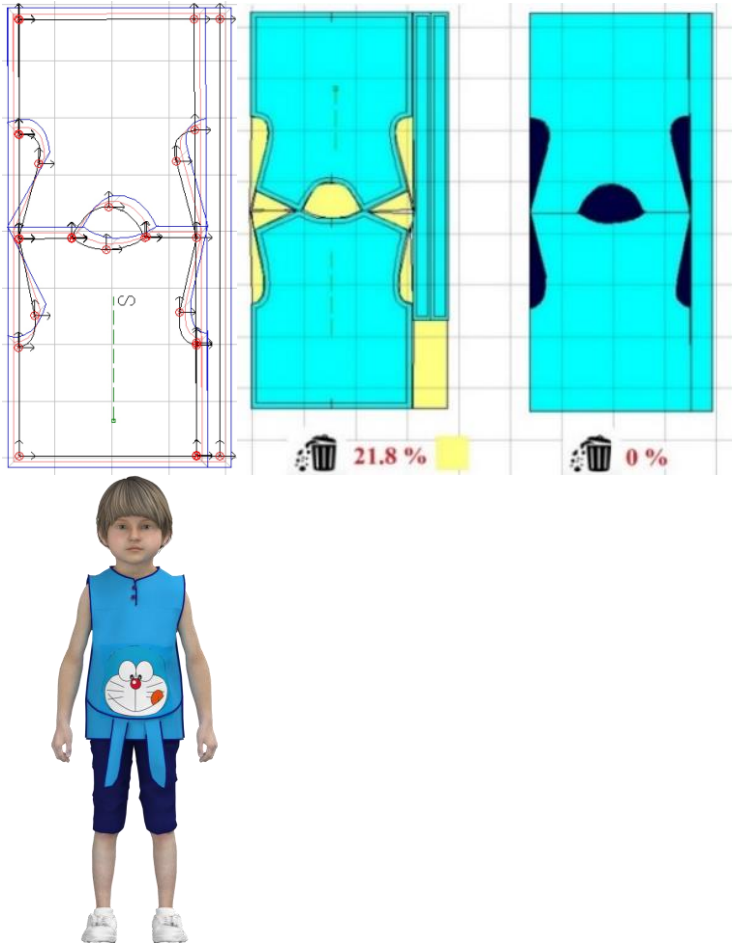

Figure 1. Design one from left to right: Grading of zero-waste patterns (a); Comparison of fabric waste in zero-waste design (0%) and conventional methods (21.8%) (b); 3D simulation (c).

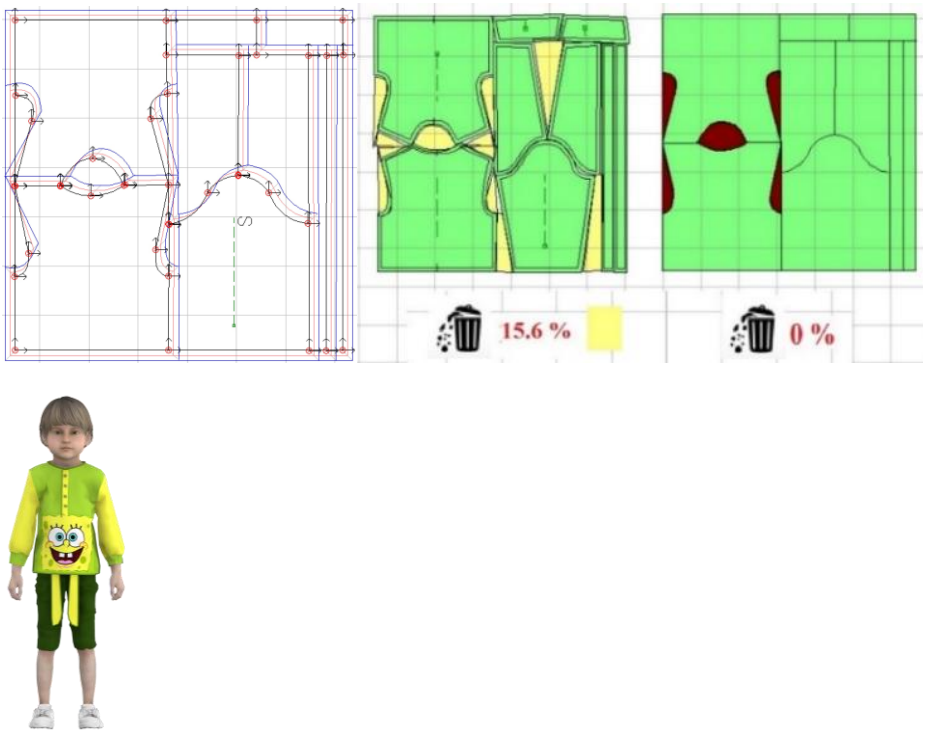

Figure 2. Design two from left to right: Grading of zero-waste patterns (a); Comparison of fabric waste in zero-waste design (0%) and conventional methods (15.6%) (b); 3D simulation (c)

Zero-waste t-shirts, shirts, overalls, and suit outfits contain a front and a back with a dispatchable cartoon panel along a flap. The flap is fastened by a textile fastener "magnetic button". These panels are connected to the back and front of the bodice along a common axis to form a front and back storage pocket. Moreover, two types of fabrics are designed separately. Therefore, it allows easy recycling after use. The design firstly uses paper pattern construction and then moves to digital, consisting of a seamless method of embedded shape that entrenches and releases the form of the woven fabric. Initial flattening is done by cutting the side seams open, resulting in a rectangular cloth piece that looks like the shape of a T-shirt.

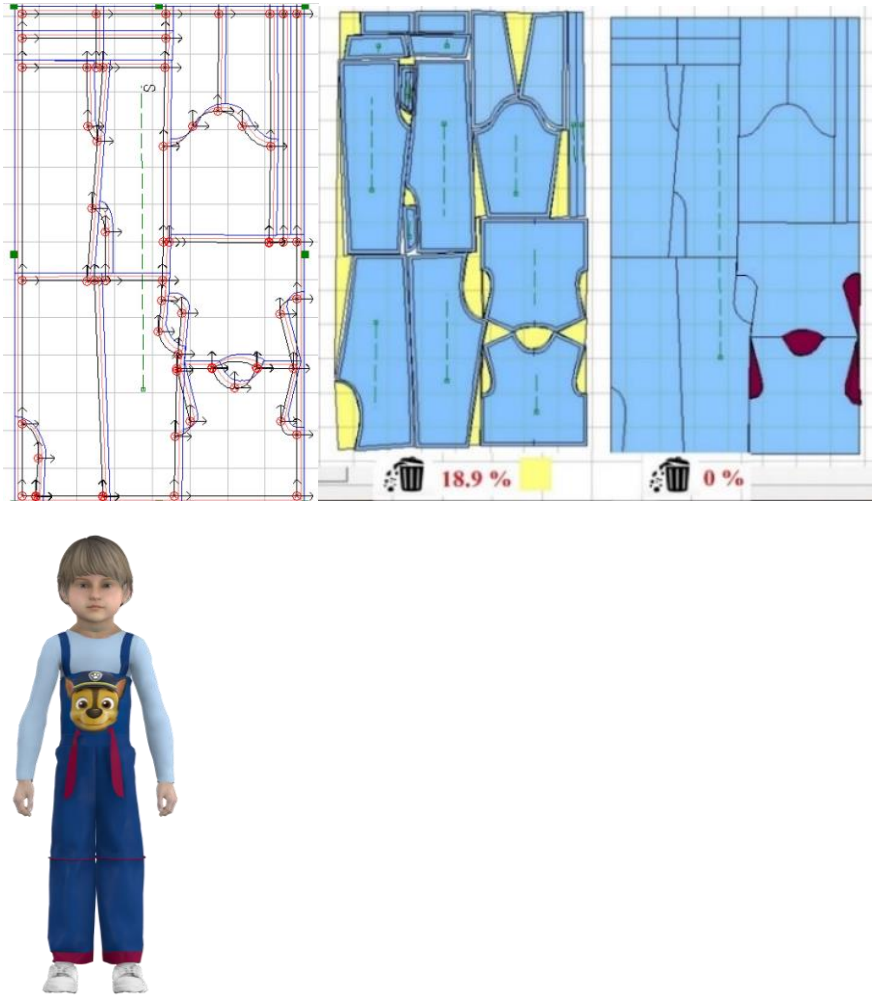

Figure 3. Design three from left to right: Grading of zero-waste patterns (a); Comparison of fabric waste in zero-waste design (0%) and conventional methods (18.9%) (b); 3D simulation (c)

The advantage of this invention is the simplicity of the manufacturing panel, which consists of several parts. The designer followed the guidelines of standards in the children's clothing design mentioned before. All outfits were attached by using the zipper, and designs were fewer accessories. The use of raw materials in the textile and garment industry must be maximized to save costs and help protect the environment and waste materials. Each creative approach optimizes the layout of the marker and reduces fabric waste. This study showed that four outfits were designed based on the zero-waste

technique with multi-digital grading, which can be applied on a large scale and promoted in the children's clothing market.

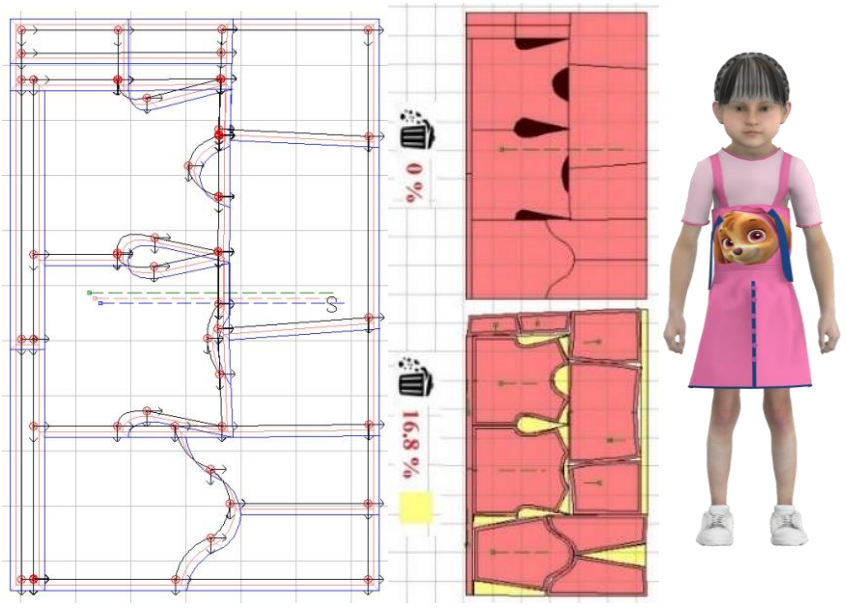

Figure 4. Design four from left to right: Grading of zero-waste patterns (a); Comparison of fabric waste in zero-waste design (0%) and conventional methods (16.8%) (b); 3D simulation (c).

5. DISCUSSION

By utilizing digital CAD tools, new options for implementing zero waste design practices are created, and new processes and applicable methods. The development of CAD has dramatically helped the industry in competition in the current era of globalization. The four types of children's clothing were accepted to be investigated. The standard pattern size (S) in the conventional method was accepted, and the amount of fabric wasted was calculated per cent. Then, the designer identified the suitable changes based on creativity and pattern grading was applied after reaching to optimize the layout. According to findings, fabric waste was reduced by redefining the lines in children's patterns and changing patterns on the front or back regions, which is in line with the finding of Jalil and Hosseini (2020). Conventional and inventive methods were used to remove waste in new designs to prove this study's four patterns. One of the findings from this study was that despite reducing fabric waste during pattern design, the overall shape of garments was not altered as previous research mentioned these points (Timo Rissanen & McQuillan, 2016). As a result, with this method, the remaining materials that were not used in the significant parts of the body design were applied for various reasons, such as producing ears or hands of the cartoon figures. Overall, the design function enables a long lifespan.

They are readily disassembled and recycled after use, extending the functional life of eco-friendly children's clothing. The cotton fabric used for the bodice may either be composted or used.

Furthermore, the pocket component made of polyester fabrics may be melted and then recreated, or it may be burned for energy. Overall, four multifunctional children's clothing items satisfied the research's standards. The characteristics of multifunctional convertible fitting zippers were also created. The finding is in line with the result of Jalil and Shaharuddin (2020)'s study, where all clothing does not have a zipper in a vulnerable part of a children's body. The polyester panel is easily removed during the washing process and may be recycled. Furthermore, the hidden buttons appear great because they are not visible and may be attached to two different materials. Moreover, all pattern grading is achieved and applicable in the children's clothing industry as well.

Moreover, it is possible to grade children's clothing based on the zero-waste technique to smaller and larger sizes based on the clothing industry's fabric width, which is a significant factor in the children's clothing market, which is in line with Jhanji (2018). The lack of variety in sustainable products in Malaysia was a substantial challenge, especially for children's clothing. Some children's clothing companies such as The Little Clothing Shop, Real.m, and Kooshboo produce sustainable products in limited grads, which is the lack of grading in this area. Even so, the limited children's clothing industry in Malaysia, especially in a sustainable manner, is still relatively small. Thus, the textile and clothing industries need to utilize it to improve their development and distribution to the market.

New ideas might be adopted to reduce waste rather than being inspired by natural materials when designing new clothing. This research enables the designer to advocate for environmentally friendly children's clothes in society and the clothing industry. However, due to the concept of zero-waste design, the number of trendy designs is limited. Training workshops to give awareness and encourage designers and manufacturers to be familiar with zero-waste approaches paired with digital are strongly recommended for this study. More research, such as the multifunctional design idea, may be produced by experimenting with new techniques and technologies.

6. CONCLUSION

Using as many raw materials as feasible in the textile and garment industry is one way to cut costs and benefit the environment at the same time. The children's textile and clothing industries are considerable polluters of the environment as a significant part of the clothing industry. The garment production process generates waste through the disposal of fabric or clothing and other demands. Several studies have been undertaken to reduce waste on marker placement or the nesting process in textile manufacturing as a first stage in the design process. As a result, each inventive technique goes toward optimizing the marking placement and reducing fabric waste. However, the significant difficulty has been eliminating or decreasing waste produced during the pattern creation step. The suggested techniques are confusing to everyone due to advanced engineering procedures, particularly the pattern designer, who frequently lacks sufficient expertise in

the zero-waste technique. As a result, waste reduction in earlier approaches was unachievable and not practical mass-production, especially in the children's clothing market. As a result, the researchers in this study set out to solve some of these issues using CAD software. Rather than relying on natural materials to inspire new clothing designs, creative concepts might save waste.

Furthermore, it is also an excellent opportunity for a blended learning approach in the children's clothing sector, thanks to zero-waste pattern creation. Using the experience in a sustainable framework allows for more comprehensive thinking and design by pattern makers or designers. In addition, it would be beneficial to conduct studies on the creation of styles and accessories for multipurpose clothing.

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