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DEVELOPMENT OF REVERSIBLE DESIGNER RAIN WEARS IN ZERO WASTAGE METHOD BY APPLYING HYDROCHROMIC INK ON HYDROPHOBIC FABRIC

BY

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ABSTRACT

Playing in the rain is beneficial. It helps with a child's motor skills and balance ability. They are now investigating, exploring, and enjoying a slippery world. This has a different set of physical challenges from a dry world. Rain wears for children is made from high-quality waterproof materials that keep the rain out, ensuring that your child stays dry and comfortable. This is especially important for young children who are more vulnerable to getting sick from being wet and cold. The innovative technology of this fun color enhancingor highlighting rain wears means that kids will never want to be inside when it rains again. They will marvel as the raindrops instantly enhance or highlights the colors water hits the fabric. Reversible rain wears are not only good but a perfect choice for a child. They are made with high-quality fabric and can be worn inside out. In addition, the kids can create different looks in no time with a single piece of clothing since these rain wears are comfortable, multifunctional, and offer versatility. Similarly, the kids can avoid the same rainwear in between their friends. Zero wastage from fabric scraps can help the designer to attachsmall attachments like ruffles, gatherings on the sleeves, flowers, etc..., which enhances the overall look of the garment also waste materials can be avoided which makes our environment polluted especially if it is synthetic fabrics. Therefore, waste management is a very important factor nowadays in every industry and especially in the textile industry. Designer rain wears will give the kids look so cute, beautiful, and elegant. Therefore, different patterned rain wears are recommended for the kids. Nature-based designs are very suitable for rain wears since rain is a natural element. Kids wearing rainwear with nature-based designs in the rain will be a visual enthusiasm for other children as well as adults. A carry pouch is important to keep the wet rain wears. To keep the rain wears inside the carry pouch, first, the rain wears should be folded and then should be squeezed to avoid excess water inside the carry pouch. This study was focused on developing reversible designer rain wears in a zero-wastage method that enhances or highlights its colors when wet with nature-based prints and also carry pouches to carry the rain wears.

INTRODUCTION

The textile industry is constantly striving for innovative production techniques to improve products and quality, and it is developed using technologies like nanotechnology, textile engineering, etc... Nowadays, the development of smart textile products is at its core point, to the constant study for practical solutions and theurgent need to change from non-renewable products. Smart textiles become more and more popular these years.

It is impossible to talk about smart textiles without talking about electronic textiles. Electronic textiles are fabrics that have some digital or electronic components in them. The difference between smart textiles and electronic fabrics is that smart textiles actually have to have a use to them- it has to benefit the person wearing it in some way. Meanwhile, electronic fabrics only have to have a digital component and do not have to benefit the user in any way.

Smart textiles provide an added benefit to the user beyond the typical value of the fabric. They respond and adapt to their environment. Fabrics are a combination of fibers and polymers, natural and man-made, that are constructed through a variety of techniques, the most popular being knitted or woven.

Hydrophobic fabrics resist water penetration with extremely low absorbency and high Stability, these are used for products that are intended to provide a dry barrier while withstanding moisture. It will be used to develop various styles of raincoats with carry pouches for kids.

Hydrophobic surfaces are manufactured by adjusting combinations of chemicals and monitoring the structural properties of solid surfaces. There are more hydrophilic surfacesthan there are hydrophobic surfaces. However, hydrophobic surfaces have manyadvantages compared to hydrophilic surfaces.

Hydrophobic materials are used for oil removal from water, the management of oil spills, and chemical separation processes to remove non-polar substances from polar compounds Hydrophobic is often used interchangeably with lipophilic, “fat-loving”.

Hydrochromic inks are used to produce prints or coatings which change colour when exposed to water, the ink dries to a colored film, the strong color and opacity disappears on contact with water. It will be applied on the rain coats with different themes using design moulds and stencils on it.

The hydrochromic ink was developed for piezoelectric inkjet printing and is based on the solvent ethanol, to which the dye Patent blue V, a defined amount of sodium hydrogen carbonate, and additives were added.

Hydrochromic inks are transparent when applied over the surface or material, and change colour when wet or if moisture is present. The surface or material will be plainwhen these inks are applied, and when wet, all will be revealed. This product is often used to bring out the colours of text or an image, if for example, the original was black and white.

A mould or a stencil is a device that helps one to apply a particular design onto a surface. The design can be in any form letters, words, and patterns being the most popular. Moulds and stencils tend to work best onto a flat surface, and depending on the ink or paint one use, it can be used on metal, cardboard, or any other material.

To create a mould, first create the pattern, then create the mould, then assemble the parts of the pattern, then expose to molten metal, then wait to cool, and then eject the casting. To create a stencil, first design a pattern according to the theme, then line up the stencil design and the material used to make the stencil, and trace the stencil design, then cut out the traced stencil pattern, and now the stencil is ready to use.

A mould cavity defines the shape of the part, then the material is injected under pressure into the cavity, when he material cools it solidifies to take the form defined by the mould, then the part is ejected, and then the process repeats. In practice, the stencil is usually a thin sheet of material, such as paper, plastic, wood or metal, with letters or a design cut from it, used to produce the letters or design on a underlying surface by applying pigment through the cut-out holes in the material.

Designing is planning or specifying the construction of an object or system or implementing an activity or process or the result of that planning or specifying in the form of a prototype, product, or process. The verb to design expresses the process of developing a design.

Colourful designs are often used to place emphasis on particular aspects of a design orto evoke a desired mood or emotion in the viewer. Designers use colourful designs selectively to create harmony, balance, and consistency.

Theme based designing is the process of designing and constructing and object or space so that "the particular subject or idea on which the style of something is based" is made clear through the "synthesis of recognisable symbols with spatial forms.

In sewing and fashion design, a pattern is the template from which the parts of a garment are traced onto woven or knitted fabrics before being cut out and assembled. Patterns are usually made of paper, and are sometimes made of sturdier materials like paperboard or cardboard if they need to be more robust to withstand repeated use. Theprocess of making or cutting patterns is sometimes compounded to the one-word Patternmaking, but it can also be written pattern(-)making or pattern cutting.

Garment design is an integration of all the design elements, including colour, texture, space, lines, pattern silhouette, shape, proportion, balance, emphasis or focal point, rhythm and harmony. Each of these contributes towards the visual perception and psychological comfort of the garment. Principles of illusion can be utilised in garmentdesign to flatter the figure of the wearer.

A reversible garment is a garment that can be worn two ways, which differ by turning the garment "inside out", however there is no true "inside out" to a reversible garment, since either way, it gives a fashionable appearance. These raincoats can also be worn in two ways, hence these raincoats are reversible fashionable rain wears.

Not that many people realize it yet, but reversible garments are a major life hack. Even though consumers are increasingly conscientious about overconsumption, a minimalist wardrobe might seem unattainable or even undesirable. But, minimalist fashion doesn't have to be limiting or boring. The reason is reversible garments. Reversible garments are the garments which can be worn in two or more ways. Reversible garments are super versatile, it is travel-friendly, it outlasts seasonal fashion trends, it gives more for the money, and it is sustainable and eco-conscious.

To make a reversible garment with the layered method, cut two of each pattern piece, with one piece in each fabric. Baste or glue baste the matching pieces to one another, with wrong sides together. Sew the garment, using these two basted pieces as one, justlike underlining.

Reversible and convertible twee in one concept of exciting clothing these days helps people pack less and helps people have a different style in one dress. Garments like hats, sweaters, jackets, shirts, trousers and skirt were already in trend in the market. Still, now, due to the concept of reversible and convertible clothing, dresses and other categories of garments are being focused on. Also, the concept is being focused on other accessories like bags, etc.

Designers and fashion houses worked on the concept of reversible clothing and today,reversible clothing is in. Convertible clothing is similar to this idea. With busy schedules and tight budgets, customers are always on a lookout for financially viable dresses that serve various purposes. A single dress is expected to be perfect for office, evening wear or a casual shopping day with friends. While initially the idea was thought to be a mere fragment of someone's vivid imagination, it gradually turned to reality. Convertible clothing is still a new concept, but customers have enthusiastically embraced it.

Zero-waste fashion refers to items of clothing that generate little or no textile waste in their production. It can be considered to be a part of the broader Sustainable fashion movement. Zero-waste fashion can be divided into two general approaches. Pre-consumer zero-waste fashion eliminates waste during manufacture. Post- consumer zero-waste fashion generates clothing from post-consumer garments such as second-hand clothing, eliminating waste at what would normally be the end ofthe product use life of a garment. Zero-waste fashion is not a new concept-early examples of zero-waste or near zero-waste garmentsinclude Kimono, Sari, Chiton and many other traditional folk costumes.

Mass-producing garments using a zero-waste approach poses many obstacles. One notable obstacle is how to efficiently create garments of different sizes, sometimes edges of the clothing are not taken into account, and many patterns created to be zero-waste are not designed to be mass-produced or do not have enough directions. A study tested the efficacy of the Carrico Zero-waste Banded Grading technique which uses the strategic placement of bands to cut patterns without wasting textiles. In this technique, to create three different sizes of a garment, there are carefully planned seam placements with varying widths of banded trims to grow or shrink allowing sizing of the clothing item up or down. After conducting the study, they found that thetechnique was successful at creating one- or two-piece items and was able to achieve showing the body's contours which are sometimes not seen in other zero-wastegarments. Some obstacles observed though were that proportion of the garment components differed among the different grade sizes. Another obstacle observed was the inconsistencies in seam allowances when mass-produced. This would add time and increase costs to train technicians on how to fix this issue.

The waste hierarchy consists of the three 'R's' - Reduce, Reuse, Recycle, in order of impact. Zero-waste fashion design eliminates pre-consumer textile waste, while not necessarily addressing waste created during the use life and disposal phase of the garment's life cycle. During textile production, many pollutants in the form of liquid, solid, and gas are emitted to the environment. The textile and apparel industry is the most polluting and has a low recycling rate of about 15%. The Zero-waste fashion design would significantly eliminate gas emissions during the production process and give and material waste proper use.

Keeping the above in mind, this study has been framed with the following objectives:

- To develop designer-wear raincoats.
- To make the rain wears more attractive by applying hydrochromic ink.
- To wear raincoats from both sides.
- To develop the garment with zero wastage.
- To carry it easily.
- To create theme-based raincoats.
- To develop new design molds and stencils.

REVIEW OF LITERATURE

The entire review of the literature collection has been divided it into subheadings:

2.1 Smart Textiles

2.2 Hydrophobic Fabrics

2.3 Hydrochromic Inks

2.4 Molds and Stencils

2.5 Designing

2.6 Reversible Garments

2.7 Zero Wastage

2.1 Smart Textiles

Volker Lutz et al., (2019) stated that the term "Smart Textiles" has now reached the general public and has massively increased the demand for new, functional textile products.

Smart Textiles are textiles with an extended range of functions. An essential goal of the extended functional scope is the interaction of the textile with the environment, which also includes the human user.

Inga Gehrke et al., (2019) explained that one of the most important properties of materials for"Smart Textiles" is their electrical conductivity.

Patrycja Bosowski-Schoenberg et al., (2019) have suggested a structure for a classified catalog as a knowledge basis to support the smart textile product development process.

Vadim Tenner et al., (2019) described that laser soldering is particularly suitable for the production of Smart Textiles since the focused laser beam causes only a spatially limited andshort-term thermal load on the textile.

Vadim Tenner (2019) quoted that there is a great deal of current research in the field oftextile touch pads. As it occurs with commercially available touch pads, various electrical principles are used. As well as touch pads, these principles are also used for touch and pressure sensors. Such sensors are increasingly used in medical technology. In the following, this product type is used to describe design concepts and examples for a specific Smart Textile, building on the materials, sensors and production technologies.

Volker Lutz et al., (2019) said that despite significant advances in both hardware and software technology and user interaction design, Smart Textiles have not taken off yet beyond the prototype stage. One of the major reasons for this is the complexity of products, technologies and businesses, which has prevented Smart Textiles from becoming market-ready products.

2.1.1 Origin of Smart Textiles

Vladan Koncar (2016) pointed out that smart textiles can be defined as textiles that are able tosense and respond to changes in their environment. They may be divided into two classes: passive and active smart textiles. Passive smart textiles have the ability to change their properties according to environmental stimulation. Shape memory materials, hydrophobic or hydrophilic textiles, etc. are part of this category.

Sweta Patnaik et al., (2019) estimated that textiles are able to sense stimuli from the environment, react to them, and adapt to them by the amalgamation of various functionalities in the textile structure. The stimulus can range from electrical, thermal, chemical, magnetic, or, their origin. Advanced materials, such as breathing, fire-resistant or ultra-strong fabrics, are according to this definition of smart textiles not considered as intelligent, no matter how high-technological they might be. The first textile material that, in retroaction, was labeled asa 'smart textile' was a silk thread having a shape memory.

Anne Schwarz (2020) stated that though industrial exploitation of smart textile systems is stillin its infancy, the technological implementation is increasing. This is the result of substantial research and development investments directed toward this emerging field. In order to stimulate progress in smart textiles, emerging developments need to be identified and selectively strengthened. Hence, this issue reports on a three-dimensional roadmap on sforrt textiles. It aims at contributing to set future actions in research, education, and technology development. Research activities and technological developments are mapped, barrand iers and drivers of technological, strategic and societal and economic origins are identified. Finally, recommendations are phrased on how to overcome barriers and to progress in the field of smart textiles.

George K. Stylios (2020) explained that recent advances of SMART textiles enable researchers to explore new ways of interaction with users. There is increasing interest to construct SMART structures, systems and prototypes with tailor-made functionality and aesthetics, which can interact with user's behavior. Color, pattern. and shape-changing effects of SMART fabrics are now capable for interaction with our emotional responses.

M. Malmivaara et al., (2009) suggested that a jacket with a sewn pocket for a mobile phone does not make an intelligent garment. Clothing is intelligent when it adds something traditionally unclothing-like to the garment, without taking away or compromising any traditional characteristics such as washability or wearability. Ideally, an intelligent garment offers a non-traditional garment function, such as health monitoring, in addition to its traditional function as protecting the body.

R. D. Hurford et al., (2009) described that fabric technology also plays a major role in smart clothes and wearable technology. The clothing industry was changed dramatically by the introduction of man-made materials such as nylon and polyester. The development of man-made materials has continued at an astounding pace. Current developments include nano-fibers and nano-coatings, which can provide us with a host of useful and unusual characteristics that enhance earlier technologies or that have been unavailable to us before.

2.1.2 Importance of Smart Textiles

S. Black et al., (2007) quoted that the drivers for the rapid current development of smart textiles have traditionally come from military research and space exploration where rigorous performance under extreme conditions is paramount. The protection of the individual in hostile environments, and the necessity for communication and monitoring have provided impetus both for materials and textile research, which then transfer to civilian use.

Y. Qin et al., (2007) said that because of the similarity in their uses and functional requirements, wound dressings are often made from similar materials to those used in traditional textile fabrics. Indeed, traditional gauze materials are made from cotton yarn, using a simple woven technique. Traditional wound dressings use many different materials and have different types of textile structures for different applications.

Nazire D. Yilmaz et al., (2018) pointed out that smart textile components include conductive polymers, conductive ink, conductive rubber, optical fibers, phase-changing materials, thermochromic dyes, shape-memory substances, miniature electrical circuits, and so on. In terms of textile functionality, organic polymers pose advantages compared to stiff inorganic crystals. The former materials exhibit low weight, flexibility, resilience, cost efficiency, and easy processibility.

Lynn Yurin Wan et al., (2018) estimated that as society evolves, people are caring more about their life quality. Clothing as one of the necessities of life is drawing more and more attention. Besides the aesthetic requirement, functionality, and adaptiveness become the most important selling points that most brands are competing on. From the point of view of the manufacturer, functional and adaptive textiles help them gain loyal customers and earn greater interest for the added value.

Tunde Kirstein et al., (2013) stated that the goal of every smart object is to make the lives of humans easier, safer, and more comfortable. The smartness of an object refers to its ability to react to external stimuli. However, a clear definition is not easy as there are different levels ofsmartness. If an object's property changes according to different environmental influences, this does not automatically make the object smart After all, several mechanical, thermal, or electrical properties change depending. For example, on the surrounding climate. Smartness starts when the reaction of the object properties is not linear to the ambient changes and whenthis non-linearity brings benefits to the user. In the textile area, phase change materials are often called smart as they store heat in a hot environment and release heat when it gets cold. In contrast to normal materials, smart materials change a specific property. Like shape or aggregate state, rapidly and significantly. Smart materials are often called designed materials as their property changes can be tuned during fabrication.

Anne Schwarz et al., (2013) explained that from a textile point of view, the overall aim for smart textiles is to convert all related components, such as sensors, actuators, transmission lines, etc. into 100% textile materials To achieve this aim, we have to face a large challenge from a technological point of view, as concepts, materials, and treatments must be made appropriate for use in, on or as textile materials.

2.2 Hydrophobic Fabrics

Carmen Loghin et al., (2017) suggested that waterproof and water-repellent materials are currently used in the three major textile areas (clothing. home and outdoor products, and technical textiles). There are a large number of possible applications, from rain garments to medical and military equipment. Regardless of the applications for which waterproofness is the function, the complexity of the conditions during use requires the multi-criteria design of the fabric structure and its testing to ensure a high number of functional such as vapor permeability, tensile strength, abrasion resistance, flexural strength (repeated cycles), resistance to low and high temperature, resistance to light, chemical resistance and more.

Hikmet Ziya Özek et al., (2017) described that waterproof clothes and coverings were neededfor outdoor work and activities of all kinds, from hunting and farming to sailing and sports, aswell as for shelter. The materials with which indigenous people kept themselves warm and dry are the early versions of waterproof textiles. These may even be some of the earliest functional textiles capable of stopping water from passing through the fabric. It is worth remembering that the need for breathable fabrics arose from the vulnerable impermeability of nonbreathable waterproof fabrics.

Silvia Pavlidou et al., (2017) quoted that usually, the wetting behavior of water onto a surface is simply determined and classified by the contact angle of water deposited on the solid substrate. The lower the contact angle the higher the wettability. Surfaces with contact angles against water of 90 degrees or higher are usually considered hydrophobic surfaces. Similarly, to gain information on the wetting behavior of surfaces by different oils and solvents, it is possible to determine the contact angles of all requested liquids on all requestedsolid materials.

Margaret H. Whittaker et al., (2017) said that the ideal water repellent exhibits seven performance characteristics, including repelling and releasing water, oil, and stains, as well as exhibiting durability. The successful commercialization of a non-hazardous, non-fluorinated water repellent displaying all seven of these performance attributes remains an elusive goal.

Chang-Sik Ha Saravanan Nagappan (2018) pointed out that the synthesis of superhydrophobic materials and super hydrophobic organic-inorganic nanohybrids is quite unusual because the highly hydrophobic materials synthesized from organic-inorganic hybrids can superhydrophobicity, depending on the substrate selection and pre-treatment required to modify the substrate to allow good adhesion of highly hydrophobic materials on

the substrate. Some of the materials synthesized using organic-inorganic hybrids exhibit highly hydrophobic properties and can readily form superhydrophobic surfaces on a substrate at room temperature or by a mild thermal treatment after coating the materials on the substrate.

Mehdi Khodaei et al., (2020) estimated that superhydrophobic surfaces and coatings have a unique behavior against water droplets. This unique behavior results in a new set of applications including self-cleaning, anti-icing, antibacterial, oil-water separation, corrosion resistance, etc.

2.2.1 Origin of Hydrophobic Fabrics

Sara Jamoudi Sbai et al., (2020) stated that for hydrophobicity property, a hydrophobic function is conferred on the textile in order to obtain waterproof articles (rainwear, blinds, tents, etc.). Fluorinated compounds are often used for this application and are applied by different grafting methods on textile properties.

Jessica Vidales-Herrera et al., (2020) explained that a Super hydrophobic coating was formulated using functionalized SiO_2 nanoparticles. High durability of the super hydrophobic properties was displayed even after several harsh tests such as exposure to intense UV radiation and strong acids and bases as well as mechanical durability tests.

Justyna Krzak et al., (2020) suggested that to create a super hydrophobic surface, a combination of low surface energy materials and a specific dual-scaled (micro- and nano-) surface roughness is needed. One of the ways to obtain hydrophobic or even super hydrophobic properties is surface coating with suitable sol.

Boris Mahltig et al., (2015) described that in since, the characterization of water-repellent properties of solid materials is usually done by contact angle measurements. However, in the field of textile engineering or even in textile industry contact angle measurements are often not taken into account, probably because they are complicated to measure and are notstrongly related to the demands resulting of the daily use of textile materials. For this reason, in the textile field many different testing procedures are established to determine hydrophobic properties.

Dr. S. K. Nema et al., (2015) quoted that hydrophobization of textile by in-situ plasma treatment method does not require pre activation of the surface and any precursor (without reactive /functional groups) can also be used. Both precursor and substrate are activated at thesame time inside the plasma chamber. The fragmentation and recombination of the precursor occur in gas phase and the fragmented radicals or the recombined radicals react with the created radical sites of the substrate. This method helps to establish a chemical reaction between the fragments of precursor and molecules of the substrate. This leads to a durable functionalization of the surface of the substrate.

P. B. Jhala et al., (2015) said that LTP treatment has been used as an alternative processparticularly in imparting hydrophobic finishes like water and stain repellent finishes.

2.2.2 Importance of Hydrophobic Fabrics

L. Boulangé-Petermann et al., (2008) pointed out that highly hydrophobic finishes are of increasing importance especially in the field of technical textiles. A large proportion of these products are finished with a heavy polymeric coating of, e.g.. poly(vinyl chloride) (PVC), polyurethane, or silicone, which effectively masks the textile fabric with a smooth surface.

Kushairi Mohd Salleh et al., (2021) estimated that natural textiles are specifically made from hydrophobic native cellulose-based materials due to the hydrophilicity of cellulose. Meanwhile, man-made fibres, especially synthetic fibre, can be designated from the early stage of materials selection with hydrophobic property. Those fabrics with hydrophilic property can be coated or treated with hydrophobic materials. It can be assumed that waterproof fabrics from applications work as protective cloth can emerge into wider applications upholstery, sport wear, etc.

Ana C. Q. Silva et al., (2021) stated that with WCA superior to 90° a surface is considered hydrophobic (has a low attraction to water droplets), and the higher its value, the more hydrophobic it is.

Md. Shafiul Islam et al., (2021) explained that water repellent or hydrophobic textile finishing is essential for ensuring undesirable staining, wetting or chemical contamination in the presence of liquids in the form of rainwater, chemicals, tea, coffee, milk, beverages and pesticides.

Kartick K. Samanta et al., (2015) suggested that the research on super-hydrophobic or lotus effect on textile substrates has been intensified for developing elegant apparel textile to protect its user from the unwanted wetting, staining or chemical contamination, when in touch with rain- water, food, beverages, chemicals and pesticides. This kind of textile doesnot allow the liquid droplet to get absorbed by the fabric by enabling the liquid drop- lets to roll-off and leaving the underlying material un-wetted. When the water con- tact angle (CA)in a hydrophobic substrate becomes more than 150° with water rolling angle <10°, the surface is called super-hydrophobic surface. To produce such a surface, a combination of two fundamental properties, such as surface roughness and hydrophobic chemical are required. Unlike in a smooth surface, the dust particles do adhere to the water droplet and finally, are removed by rolling-off from the rough super-hydrophobic surface.

Mohammad Khajeh Mehrizi et al., (2021) described that super hydrophobic and water- repellent coatings have attracted considerable attention in recent decades. Recently, super hydrophobic textiles, due to their importance in industrial applications, have been widely studied by many researchers. Primarily, medical textiles to protect infection by fungus, anti- fouling clothes, breathable clothes, umbrellas, and fabrics for the surgical need to super hydrophobicity. Also, hydrophobic surfaces have many applications, including water- proofing of surfaces in building and civil engineering, protection of wood against water, filters for separating oil from water [8], anti-corrosion, anti-fogging coatings, ice-resistant cables, micro fluidics domestic commodities.

2.3 Hydrochromic Inks

Marinella Ferrara et al., (2013) quoted that new dimensions are added to garments and swimsuits through the use of hydrochromic and photochromic inks.

Hydrochromic inks change colour when they come into contact with water.

Upon contact with water, this layer becomes transparent and reveals the colour of the print underneath. This idea was also used on a swimsuit. Although hydrochromic and photochromic effects are rarely used in fashion design nowadays, many more applications arebound to follow in the near future with the help of marketing, diffusion of knowledge, and cost reduction.

Ajit Behera (2021) said that in industrial products, hydrochromic materials are used for special inks in the form of pigments, which in many cases, act similar to thermochromic ones: they are normally white and opaque but become transparent in the presence of water. Inmost of the applications, which were realized until today, these materials were applied on surfaces that already have a coloured layer printed on them, forming a fine white film that rejects light waves, impeding them from reaching the printed image. At the moment in which the surface is wetted with water, the film which used to diffract the light acquires a viscosity such that it becomes permeable to electromagnetic frequencies and lets the light waves be filtered through, making visible the colour image lying underneath. When the surface is dried,the ink film returns to its light impermeable condition. Becoming white and opaque again. The best results with hydrochromic inks in terms of applicability and durability are obtained when the ink is applied on dry and smooth surfaces. Various types of substrates can be used: soft sheet vinyl, paper, coated paper, styrene sheet, polyester fabric, soft PVC, and many more. The inks can be applied by screen printing (contact print) or spray coating, followed bypassing it through a forced hot air tunnel, as in the production of printed shirts. Hydrochromicmaterials have been used in the textile sector to achieve dynamic patterns on textiles. Later, they were used to realize clothing and bathing suits, umbrellas, and table cloths. At first sight, under full appears like a traditional paisley patterned table cloth; monochromatic, decorated with floral designs with a shiny-opaque effect. However, when a cup of water accidentally tips over and the tablecloth becomes wet, the hidden graphic design reveals itself by becoming coloured. Thus, an unpleasant incident at the table transforms into a positive experience as in the popular Italian saying "accidentally spilling wine on the table brings good luck".

Peter Banfield et al., (2018) pointed out that variations in the colour of certain dyes with changes in pH can also be used to visualise changes in many physical environments, for instance their use as humidity indicators in the presence of pH modifiers such as carboxylic acids, which are also called hydrochromic inks.

Ahmed Akelah (2013) estimated that hydrochromic inks are available in both reversible and irreversible forms, and have great potential for demonstrating that food products have not been exposed to excessive moisture.

Sara Nabil et al.,(2019) stated that the hydrochromic under full tablecloth reveals hidden colourful patterns when liquid is accidently spilt, designed by Kristine Bjaadal in 2009.

Daniel Kula et al., (2013) explained that these change colour in contact with water or moisture.

2.3.1 Origin of Hydrochromic Inks

Élodie Ternaux (2022) suggested that part of the X-chrome material family, along with photochromics and thermochromics, hydrochromic substances change colour in contact with water or moisture. Often commercialised under ink forms ready to be screen-printed, they will create colour effects, usually being white and becoming transparent once wet, therefore revealing what they were previously covering.

This is a water based screen ink which dries to give a white opaque print. When wet the ink film takes up water and becomes transparent allowing any print beneath to become visible. If the water dries out the opacity is regained and the original white print colour is restored.

https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.colourchange.com/ works-hydrochromic/%23:~:text%3DThis%2520is%2520a%2520water%2520based,white%2520print%2520colour%2520is%2520restored.&ved=2ahUKEwjA5-W1p4_9AhUzR2wGHf-wDJAQFnoECBAQBQ&usg=AOvVaw1g-QjX1pPn0yFAlLDlWGBU

2.3.2 Importance of Hydrochromic Inks

Jenny Udale (2008) described that it is important to choose the correct media for successful textile printing.

Hydrochromic inks change colour (become transparent) when wet or if moisture is present. Apply these inks over the surface or material you want to hide- so when wet, all will be revealed!

https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.sfxc.co.uk/collectio ns/hydrochromic-ink%23:~:text%3DHydrochromic%2520inks%2520change%2520colour%2520(become,original%2520was%2520black%2520and%2520white.&ved=2ahUKEwi3kKXHv4_9AhVs7TgGHWE3BvIQFnoECAwQBQ&usg=AOvVaw3iF-bjjDowrWbFZSSqvo9x

2.4 Moulds and Stencils

Nana Mizushima (2012) quoted that a stencil is a handy way to cut out the right size and shape from a rolled flat metal-clay piece. A stencil also allows you to quickly make multiplesof a shape. You can also use the stencil lines in the design itself to create a border around a texture.

Chris Taylor et al., (2019) said that it is a sheet of plastic about 1/16 inch thick with patterns cut out of it.

Dominick V. Rosato et al., (2004) pointed out that mould design is a decisive factor for the moulding success such as dimensioning and location of the sprue gates, dimensioning of shear edges, flow aids, cooling and ejector techniques, etc.

2.4.1 Creating Moulds and Stencils

Minyung Song et al.,(2019) estimated that lithography can create moulds or stencils for patterning liquid metal. Spreading liquid metal across a stencil placed on a substrate can achieve features as small as 100 μm.

Lei Fu et al., (2022) stated that although photolithography of liquid metals has not been realized, this method can be used to make moulds or stencils in liquid metal patterning.

Dishit P. Parekh et al., (2020) explained that one can create moulds (inverse of shape and pattern) of silicones and then press the mould against a puddle of liquid metal; the metal fills the ingress of the moulds to form the feature. One drawback to this approach is that it is generally difficult to pattern liquid metals as interconnects between other components. To overcome this challenge, one can utilize photolithography to create stencils. The liquid metal is then sprayed or spread over these stencils to form a desired pattern. As a result, the metal can be selectively deposited without contacting or damaging other areas of the substrate. To date, stencils have been utilized to create patterns with pitch resolutions of -20 μm.

Stephen Pentak et al., (2021) suggested that moulds are commonly made of plaster from original works created in clay, but many other materials such as latex and silicone rubber are also used to make moulds. To make a plaster mould, a box-like form is built around part of the original object, the pattern, and filled with plaster and left to harden. This is repeated untilall parts of the original have a corresponding mould section. The hardened plaster mould sections are then coated with a release agent to prevent them from adhering to the casting material. The sections are strapped together and filled with plaster or other material that hardens, and finally the mould is removed to reveal the final cast object.

Nana Mizushima (2012) described that make a stencil by first drawing a few designs on a playing card. Fine-point permanent markers work best on a card's shiny surface. Make the stencil a little larger than the desired finished size of the piece. Remember that the metal clay will shrink about 8-30% depending on the type of clay and that you will also sand it down. Select one drawing and cut the shape out. You will use the card with the shape cut out of it,so don't worry about cutting into the centre of the shape.

Lynn Martin et al., (1991) quoted that moulds from plaster of Paris original models for special designs in decorative tile, such as fountains and waterspouts, sculpturing model by cutting, scraping and finishing. May construct wooden moulds for use in casting original claymodels, using carpenter's hand tools, or may supervise CARPENTER. MOLD (brick & tile, concrete prod.) in preparing wooden moulds from original models.

2.4.2 Uses of Moulds and Stencils

Stephan J. A. et al., (1893) said that the stencils are applicable to printing in parti-colours.

Albert Folch (2016) pointed out that a metal stencil cannot be used to pattern material from the liquid phase because the stencil does not form a close contact with the surface. A PDMS stencil is an attractive solution because, as we have seen, PDMS seals well. Moulding holes, however, is more challenging than moulding features on a surface because the moulding process must guarantee that PDMS is excluded from the top of the micro fabricated features (or else the “holes” are occluded by a thin PDMS membrane).

Wm. A. Jones (2022) estimated that you will do just as well to tell the person who does the moulding work to leave it untrimmed. That will mean that there will be a couple of inches all the way around for you to trim, plus any between pictures if you have more than one picture to a mould. This extra is not difficult to trim with heavy scissors or sharp knife.

Chris Taylor et al., (2019) stated that for those of us who are not great artists with steady hands, stencils allow us to pretend that we are. An airbrush stencil holder comes in handy for these tasks.

Paul Arguin et al., (2019) explained that you can also make your own by cutting a shape out of an old plastic lid.

Michael Twyman (2018) suggested that in alphabet versions the stencil might provide a single letter to a plate or a complete alphabet on one plate.

The most common use of the custom-made stencil was for personal or commercial name and address plates. In the American Civil War soldiers of both North and South carried their own stencils for use in marking clothing and equipment.

2.5 Designing

Karl Aspelund (2014) described that designing is a basic component of human experience and culture through history that has become a globalized profession dedicated to the needs defined by modern, urban, industrialized society. It has a process involving several stages, and bringing an idea from the world of imagination to the world of objects requires touching on each of these stages with an awareness of the needs and constraints involved and a well- defined goal in sight. The designer's job is to guide the project throughout the entire journey, creating a new product or system that fulfills all the apparent needs within the given constraints.

Karl Aspelund (2014) quoted that designing is the actions within a process that produces a formalized system. The system thus created is the solution to a problem. The design that fulfils the need. The system can be any combination of materials, techniques, and orderings of operations that creates a solution. In this sense, a shirt is a system, and so is a car, a chair, aneighbourhood development, the "look" of a rock concert, a book cover, and a travel mug.

Karl Aspelund (2014) said that the designer's initial task is to consider what might inspire engagement with the project. Is there an aesthetic excitement? A personal goal? The thrill of achieving some- thing no one has before? The satisfaction of creating something that meets a need in a way that is wholly new? Perhaps the inspiration is simply the thought of creating a money maker for the company, or perhaps it is the lift to the morale of the team by including them in a project's success. The project might have gains that are their own end, in that they lead toward a larger goal, and solving one objective might bring the next one closer.

Karl Aspelund (2014) pointed out that a designer in the identifying stage may be seen as a connector who identifies how concepts can be brought together in a new way. This is the coreof innovation: the ability to connect two or more known ideas in a new way to bring something into the world that has not been seen or done before or that performs better than anything so far. Creating connections between ideas also may involve creating connections among disciplines where the way something is approached in one place may be the solution of how it is done elsewhere. For example, lightweight frames developed for bicycles were found to be excellent for furniture in the 1920s, and methods from the space program have supported thinking about design for a number of more earth-bound products.

Karl Aspelund (2014) estimated that the image that often emerges is the designer as problem solver. Every design project is a problem requiring a solution. The solution encompasses methods, uses, approaches, materials, costs, weights, contexts, moods, and emotions, but in the end, a solution-that is, a concept begins to emerge of the direction that must be followed. The concept can be entirely mundane, such as how to improve a simple kitchen gadget. Or it can be large and profound, such as a vision for the future of an entire city or a life-changing, culture-evolving device that changes everyone's method of engagement in daily life.

Karl Aspelund (2014) stated that the turning of raw material into an object requires precise definitions and technical specifications. Technical diagrams, prototypes, mock-ups, testing, and planning are either performed or directed by the designer to test functionality and to try out new materials. Connecting is one thing. Putting it in context is another. A good designer must find where things fit. How does a material belong? How does a shape "speak of" a concept? What is the space in which a designed object will fit in the life of a person, a city, a society, a culture? Thinking in terms of context requires much more than knowledge of materials and techniques.

2.5.1 Colourful Designs

Frankie Ng et al., (2013) explained that today, another design method is available for designing colourful simulative fabric, viz. Using a computer colour matching system (a colour table way). A colourful simulative fabric can be approached more efficiently based on a fixed colour table. The design process starts with the design of coloured fabric samples under a designated fabric structure; then, colour parameter data are tested and collected for each sample by using the computer system to establish a corresponding colour table; finally, simulative fabric is designed by matching colours between the colour table and the colour image with the aid of the computer system. By doing so, it is possible to accurately translate the colours of a given image into fabric structures. Colour matching in a computer system is especially suitable for the computer programmed processing of true-to-original simulative effect fabrics. However, due to the restrictions of the colour range of a colour table, such a method is used only to design fabrics with the same fabric specification. If the technical

parameters in the fabric specification vary, new colour samples and corresponding colour tables need to be established, which is time-consuming indeed.

Mohammed Kamal et al., (2022) suggested that colour is a central part of visual knowledge that impacts an inclusive change in human actions, for example, choosing cars, clothes and interior decorations. Additionally, the physical environment influences the performance and mood of people. Colour plays a role in the environment, but there are doubts about the exact effects on human beings and their behaviour in relation to specific colours.

Heather Audin (2013) described that printing fabrics with colourful designs was a complicated process: the more colours a design had, the longer it took to manufacture, as each colour had to be applied in a separate layer. The range and varying shades of colour produced were a testament to the ever-increasing skills of the manufacturers, who would overlay different colours and use a range of processes to achieve vibrant, shaded and interesting printed patterns.

N. A. Redmore et al., (2011) quoted that the usually high set fabrics with multiple coloursand many layers make them to costly for most areas of the apparel industry.

Suyash Khaneja et al., (2021) said that however, colourful designs, configurations, and for instance, acoustics are active and stimulating t human minds, which is extremely important.

Felix Fuhg (2021) pointed out that fashion was part of a wider “colourisation” of life, in a country that was enjoying the arrival of technological innovations such as colour television. Designers combined colours with new garments and fabrics, making use of new production methods.

2.5.2 Theme Based Designs

Lesley Ware (2018) estimated out that get started by thinking of a colour you like to wear. Look everywhere for inspiration to add to your board, from photos to buttons. Use as many shades of your colour as you can find.

Feng-Tzu Chiu et al., (2019) stated that industries need to clearly understand how to produce environmentally friendly products and how to demonstrate the product they produce are environmentally friendly. The theme of Spring/Summer Season proposed by WGSN is “Profit from the Product Life Cycle”. This certainly shows that environmental protection is a necessity, not just a slogan. Fashion industry need to fully integrate sustainability strategy asa necessity, and not a “nice to have” for consumers.

Lucinda Morrissey et al., (2019) explained that a clear definition and true application of the circular design concept is proving to be elusive. Often projects that advocate this model are infact applying the up cycling of materials or extending the life cycle of a product. However, these efforts should be encouraged as it would be impossible to change from the linear model of production to the from one day to the next. Also these projects offer the designer the opportunity to think out of the box and move closer towards the circular economy.

Sara Bro-Jergensenl (2013) suggested that it is something of a myth that a designer sketches then makes exactly what they drew. Indeed, it is good to point out the difference between a designer and a technical pattern-maker or a sample maker whose job is to interpret exactly what the designer has sketched. Within design development, this is not the goal, the sketch in merely the starting point-the first step on the journey towards discovering the evolution of thedesign in slits various incarnations.

Sandra Meech (2012) described that images from nature have dominated themes in stitched textiles and other art forms for hundreds of years. In ancient Egypt, stylized flowers in repetitive patterns of red, yellow and blue were evident on bowls and murals. Dutch damask wall panels, tapestries, floral embroidery, chintz and silks from the Par East, flower fabrics and pattern for wallpaper and textiles continue to influence textile design Japanese design hastraditionally expressed natural themes, and it has been a strong influence in the worlds of fineart and graphic design Nature's influence on Western design is also evident-consider the fabric and wallpaper designs of William Morris, or the flower power fashion designs popular in the 1970s, or even more recently as retro designs.

Phyllis G. Tortora et al., (2009) quoted that factors such as GEOGRAPHIC LOCATION, the NATURAL ENVIRONMENT, and ECOLOGY (the relationship of humans to their physical environment) may emerge as themes that are evident in dress. Examples can be seen in preferences for tailored clothing in cold climates and draped clothing in warm environments, or in contemporary avoidance of fur by some consumers as a means of protecting endangeredspecies.

2.5.3 Pattern Designs

Richard M. Proctor (1990) said that virtually any shape or line repeated often enough will produce pattern of some sort because pattern, by definition, results from the repetition of an element or motif. The system of distribution and the relative detail of the motif determine the apparent complexity of a given pattern. Complexity, however, is no guarantee of quality.

Lou Andrea Savoir (2007) pointed out that pattern, and its repeating celebration of form, regularly gets relegated to the rank of simple (and thus almost sinful) satisfaction. Pattern is the eye candy of the Western world, and there have been times when the upper crusts of the art and design world thought its practitioners were giving in to a base form of sensual abandon.

Sara Alm (2017) estimated that only very basic tools are needed to begin designing clothes with the flat pattern method. Creating your own designs will be rewarding if you possess garment sewing knowledge, imagination, and a sense of adventure. A great-fitting master pattern is a critical first step.

Jay Friedenberg et al., (2010) stated that the basis for each pattern is a motif that is translated,reflected, and rotated to create a new version of the motif that is then aligned with or super- imposed upon itself. The motifs can be geometric, as in the case of squares, circles, and hexagons, or they can be representative of a shape such as a mushroom, ice cream cone, or kite.

Valliappa Lakshmanan et al., (2020) explained that design patterns are a way to codify the knowledge and experience of experts into advice that all practitioners can follow.

Lewis Foreman Day (1903) suggested that pattern, it seems plain, and repeated pattern, conforming to the conditions of manufacture and even to mechanical production, is a consideration of importance, not merely to manufacturers and others engaged in industries into which art may possibly enter, but to all whose comfort and well- being depends in any degree upon the beauty and fitness of their surroundings.

2.5.4 Garment Designs

Gerry Cooklin et al., (2012) described that a garment design does not exist in a vacuum but isthe end product of a chain of activities which can be said to start with the production of textile fibres. Various authorities have estimated that the time span between fibre production and the garment sampling stage can be as long as between six to eight months but as short as six to eight weeks for “fast fashion” items. For the clothing manufacturer, the internal chain of activities starts some time before the forthcoming season’s materials are available because the company has to have some firmed-up ideas of what it intends doing before selecting materials.

Pamela Stecker (1996) quoted that a knowledge of design also assists in recognising well- designed, marketable garments and in analysing why they work. The elements and principles may be used on a garment in one of two ways. Structural use refers to those methods which are used in the actual making of the garment, such as seams, darts, panels, openings, pleats, tucks, hemlines and so on. Structural details are more notice- able on garments with plain fabrics and minimal trims.

Rajkishore Nayak et al., (2017) said that the first process in the garment supply chain is the inception of the design. The designs are made in-house or specialist designers may be outsourced for the season. After extensive research and input from the buyers, the designs areconstructed to reflect consumers’ needs. Designs are also influenced by other brands and designer collections presented in trade shows in cities such as London, Paris, and New York. The designs are made with several factors in mind such as the final customers and their demands, and the end use of the garment.

Bethan Morris (2006) pointed out that a variety of terms are used to describe the drawing of adetailed garment specification. Flats, working (or technical) drawings, specs (or schematics) all describe the diagrammatic styles of representing an item of clothing. They are two- dimensional drawings of garment construction, showing front, back and side views with technical descriptions. They also show design details such as topstitching trims and pockets. This style of drawing is most often used to accompany a fashion illustration, giving the viewer more information about how the garment is made to back up its visual description.

Prasanta Sarkar (2015) estimated that the apparel design department is responsible for product development. They focus on developing garment designs in product categories similar to those in which the company does business. Designers develop a new design collection for every season. Designers make the latest designs based on fashion trends and buyers’ taste. For big manufacturers, the design department plays an important role in retaining customers by developing new designs for their buyers in every season.

Jayne Smith (2013) stated that the fundamental requirements of fashion design are a sound knowledge of the basics of garment assembly together with an understanding of the garment assembly terms used in the fashion industry. Armed with this basic information and understanding you will be able to create your own garment designs.

2.6 Reversible Garments

Mary Griffin et al., (2001) explained that it’s easy to think that sergers were designed for reversible garments because they’re perfect for this type of sewing. There are several construction methods. This is the simplest.

Claire B. Shaeffer (2003) suggested that for reversible garments, use seams such as strap, lapped, decorative French, decorative bound, and stand-up French seams which will be attractive on both sides. Decorative French seams are a good choice for lightweight fabrics. There are two versions: stand- up French and topstitched French. To sew stand-up French seams, consider a wider finished seam. Stitch first with right sides together; then stitch with wrong sides together so the finished seam is on the outside. When joining the seamed section to another section, fold the French seam down or toward the back. To sew a topstitched French seam, stitch the seam as usual; press it to one side, and edge stitch flat against the garment.

Claire B. Shaeffer (1981) described that many fabrics can be used for reversible garments be-cause both sides of the fabric look the same or be- cause the wrong side of the fabric is attractive. A few fabrics are printed with one pattern on one side of the fabric and another pattern on the other side. All of these fabrics are a single thickness or single-ply fabrics.

Susan Neall et al., (2015) quoted that when adapting your pattern for reversible sewing. Trim all hem allowances to 5/8”. Length can’t be altered once the garment is sewn together.

2.6.1 Uses of Reversible Garments

Pam Hastings et al., (2001) said that reversible garments are a wonderful way to mix and match a wardrobe. They offer flexibility and are perfect take-alongs for travel. Any simple garment, such as a blouse, jacket, skirt, slacks, or vest, can easily be made into a reversible garment.

Pati Palmer et al., (2015) pointed out that a button/loop closure is ideal for a reversible garment because you can just sew buttons on both sides and the loop on one side.

Rosemary Eichorn (2003) estimated bound-standing seam. This seam stands on end and is reinforced and sturdy because the binding is stitched through both seam allowances on top of the stitched seam. The garment’s seam is not pressed open, but rather the seam edges are bound as one. This finish is appropriate for seams with collage extending into the seam allowance, where there a bulky seam that’s difficult to press open. If you decide to use it for reversible garments, keep in mind that this seam will stand away from the garment and become a noticeable decorative detail.

Pooja Khurana et al., (2007) stated Flat Felled. The advantage of this type of seam is that it gives a neat look to both sides of the garment: the face of the garment as well as the inside. It is a seam, which is specifically used for all reversible garments used on both sides. It is a seam advised for sportswear too. It is a sturdy seam and is used for garments whose usage is rough. One can see its major use in denim garments.

Edward H. Knight (1877) explained Ja’nus-cloth. A fabric having each side dressed, and different colours on the respective sides. Such fabric is used for reversible garments.

2.6.2 Mechanism of Reversible Garments

Agnes Mercik et al., (2001) suggested that the technique described here is double-layer construction. Two “garments” are assembled and then joined wrong sides together by edge- finishing. Your choices for this last, joining step are simple-bias binding or serging-but any sewer knows that the first option, bias binding, isn’t all that great. Serging the edges, however, is very easy and beautiful.

Rosemary Eichorn (2003) described that soft-edge applique is an easy way to introduce a hintof embellishment on the lining of an art wear garment. It creates a jazz focal pout for the line that’s especially effective when you plan to make your garment reversible.

Susan Neall et al., (2015) quoted that a superb reversible garment can be created with two layers of fabric. Sandwiching fine cotton tailor’s flannel or light- weight polyester polyester interlining (batting or wadding) with row upon row of parallel topstitching. Called channel stitching. This turns two lightweight fabrics into a fabric with more strength, a little warmth, and creative character. The interlining and quilting rows also make the two fabrics “crushproof” and turn them into the perfect travel piece. You can also purchase pre quilted yardage.

June Hemmons Hiatt (2012) said that here is a set of ordinary knitting techniques applied in uncommon ways to create quite extraordinary results. The Double-Fabric technique makes it possible to knit two fabrics at the same time by interspersing the stitches for each of them ona single needle. This approach can be used to make double-thickness, fully reversible garments with mixed Knit and Purl or colour patterns on both sides.

2.6.3 Importance of Reversible Garments

Henry W. Dutton (1864) pointed out that the various stitches, some four or more, are very important in the making of heavy garments; the reversible feed, allowing the operator to move or feed the cloth in opposite directions without even stopping the machine, gives great advantage in fastening the ends of seams, making them doubly secure, or in fastening the thread at any point.

Sandra Betzina (2000) estimated that you can fold under the raw edge of the trim and hand- stitch the fold to the garment just past the seam line. A turned-under edge looks great on a reversible vest.

2.6.4 Awareness of Reversible Garments

To make a reversible garment with the layered method, cut two of each pattern piece, with one piece in each fabric. Baste or glue baste the matching pieces to one another, with wrong sides together. Sew the garment, using these two basted pieces as one, just like when you underline.

https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.seamwork.com/artic les/make-it-reversible%23:~:text%3DTo%2520make%2520a%2520reversible%2520garment,just%2520l ike%2520when%2520you%2520underline.&ved=2ahUKEwiri5SV46r9AhWw3jgGHYnTB wwQFnoECCEQBQ&usg=AOvVaw3gTLCMc9AAk4ADjtC3yXWJ

A reversible piece is something that can be worn two ways. You usually just have to pop it inside out, and you'll be wearing a totally different garment.

https://www.google.com/url?sa=t&source=web&rct=j&url=https://labante.co.uk/blogs/news/ are-reversible-garments-the-way-towards-sustainable-fashion&ved=2ahUKEwiri5SV46r9AhWw3jgGHYnTBwwQFnoECAwQAQ&usg=AOvVa w2rlO5ddEtmh996zpfI5oBF

2.7 Zero Wastage

Moni Jafar Pingki et al., (2017) stated that zero-waste is a design method that eradicates textile waste at the design stage. There are several methodologies to manufacture a zero- waste garment. The rule is that there will be no wastage. So, firstly it should decide what typeof garment will be made and which formula will use to make it zero-waste, for example draping, knitting or using a zero-waste pattern, as these will inform one's design and sourcing options.

Hye-Won Lim (2020) explained that zero waste is a design technique that not only eliminatestextile waste but also re-uses and remodels as another piece at the design and manufacturing stage. Zero waste has become a legal requirement in the manufacturing industry to produce less waste, and this growing needs for more sustainable consideration with less waste in the fashion industry encourage zero waste design as the new creative direction. Therefore, it becomes more important that the fashion industry finds ways to produce in this way and also fashion educators consider this issue onto their education.

Lotika Gupta et al., (2020) suggested that these refer to all those methods that can be used toremove fabric wastage from apparel manufacturing using specific designing techniques.

Apparels produced through zero - waste fashion design methods consume only the amount of fabric needed for a particular piece of garment and leaves almost no fabric waste. Broadly speaking, zero waste fashion concept refers to a system where waste is reduced to almost nil in every stage of designing, production and usage stage of a garment.

Inoka Rathnayake et al., (2014) described that It is a guiding design philosophy for eliminating waste at source and at all points down the supply chain. It rejects current one waylinear resource use and disposal culture in favour of a closed loop circular system modelled on nature's successful strategies.

METHODOLOGY

This chapter refers to research procedures used for the study. All the aspects of researchprocedures followed have been divided into following sub headings:

3.1 Experimental designs

3.2 Flow chart

3.3 Designs

3.4 Evaluation of designs

3.5 Collection of raw materials

3.5.1 Hydrophobic black fabric

3.5.2 Plastic sheet

3.5.3 Hdrochromic inks

3.5.4 Trims

3.5.5 Pattern papers

3.5.6 OHP sheets

3.6 Preparation of specification sheets

3.7 Preparation of patterns

3.8 Fit sample

3.9 Preparation of stencils

3.10 Application of inks

3.11 Extraction of waste fabrics

3.12 Development of products

3.13 Testing of products

3.13.1 Spray test

3.13.2 Fit test

3.14 Preparation of cost sheet

3.15 Evaluation of products

3.1 Experimental designs

Total number of fifteen designs were illustrated in which three among them are finally approved with the help of my guide in charge.

3.2 Flow chart

A flow chart has been created to easily understand the work flow of the methods used to develop the final products.

Flow chart (Plate I).

3.3 Designs

The design is hand sketched using HB pencils and water colours.Design 1, design 2 and design 3(Plate II, III and IV).

3.4 Evaluation of designs

The design developed was evaluated based on the appearance, colour, design usability, shape/size and functionality. For the evaluation, an online survey was conducted from 50 respondents.

3.5 Collection of raw materials

3.5.1 Hydrophobic black fabric

Hydrophobic black fabric is collected from a wholesale shop (Thrissur).Polyester - 7 ½ meters (Plate V).

3.5.2 Plastic sheet

Plastic sheet is collected from a wholesale shop (Thrissur).Plastic sheet - ½ meter (Plate VI)

3.5.3 Hydrochromic inks

Hydrochromic inks are collected from an online store (Amazon.in).Hydrochromic inks - Blue, Yellow, Pink (Plate VII).

3.5.4 Trims

Thread, velcro, and zipper are collected from a stationary shop (Thrissur).Black thread, black velcro, and black zipper (Plate VIII, IX and X).

3.5.5 Pattern paper

Pattern paper is collected from a stationary shop (Thrissur).Pattern paper (Plate XI).

3.6.6 OHP sheets

OHP sheets are collected from a stationary shop (Thrissur).OHP sheets (Plate XII).

3.6 Preparation of specification sheets

The specification sheets or spec sheets have been created for all the three products includingevery details of the products.

3.7 Preparation of patterns

The patterns are prepared using pattern papers with the help of lead pencil, long ruler, Frenchcurve and scissors.

The patterns are arranged on the fabric in zero wastage method.

Front pattern, back pattern, sleeve pattern, hood pattern and zero wastage method (Plate XIII,XIV, XV, XVI and XVII).

3.8 Fit sample

Since the final garments are designer wears, the fit sample have been done by customising method in which the measurements are taken. The material used to develop the fit sample is satin fabric.

Fit sample (Plate XVIII).

3.9 Preparation of stencils

The stencils are prepared using OHP sheets with the help of CD liner and scissors.

Stencils for design 1, stencils for design 2 and stencils for design 3 (Plate XIX, XX and XXI).

3.10 Application of inks

Screen printing technique is used, it is also known as silk screening or silk screen printing. It is the process of transferring a stencilled design onto a surface using a mesh screen, ink and squeegee (Plate XXII).

3.11 Extraction of waste fabrics

The fabric pieces for ruffles, gatherings, and flowers which has been attached extra on the garment is been extracted from the waste cut pieces (Plate XXIII).

3.12 Development of products

Product development was done by Singer FM 2250 Electric Sewing Machine.
Laying, marker making, cutting and sewing (Plate XXIV, XXV, XXVI and XXVII).

3.13 Testing of products

3.10.1 Spray test

Spray test is tested using a spray rating tester (Plate XXVIII).

3.10.2 Fit test

Fit test is tested by sewing a sample garment (Plate XVIII).

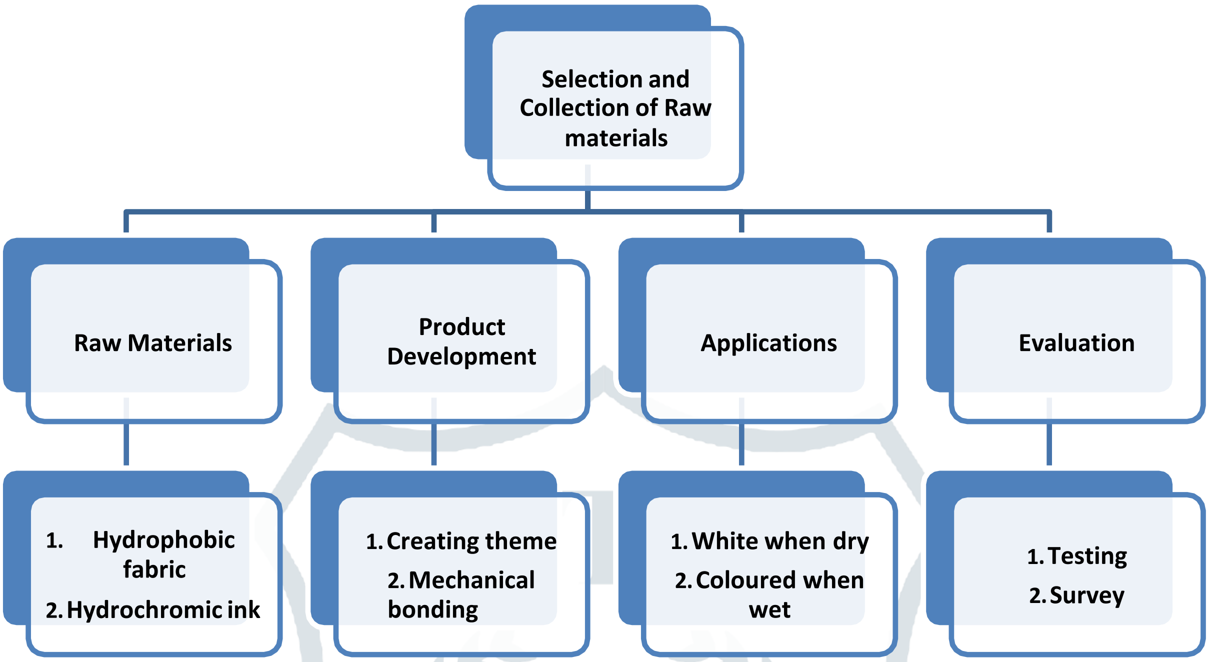
3.14 Preparation of cost sheet

The cost sheet is been prepared by calculating the sum of direct charges, indirect charges and profit.

3.15 Evaluation of products

The product developed was evaluated based on the appearance, colour, design usability, construction, texture, shape/size, finishing and functionality. For the evaluation, an online survey was conducted from 100 respondents.

Flow chart - Plate I



Design 1 - Plate II

Design 2 - Plate III

Design 3 - Plate IV

Hydrophobic black fabric - Plate V

Plastic sheet – Plate VI

Hydrochromic inks - Plate VII

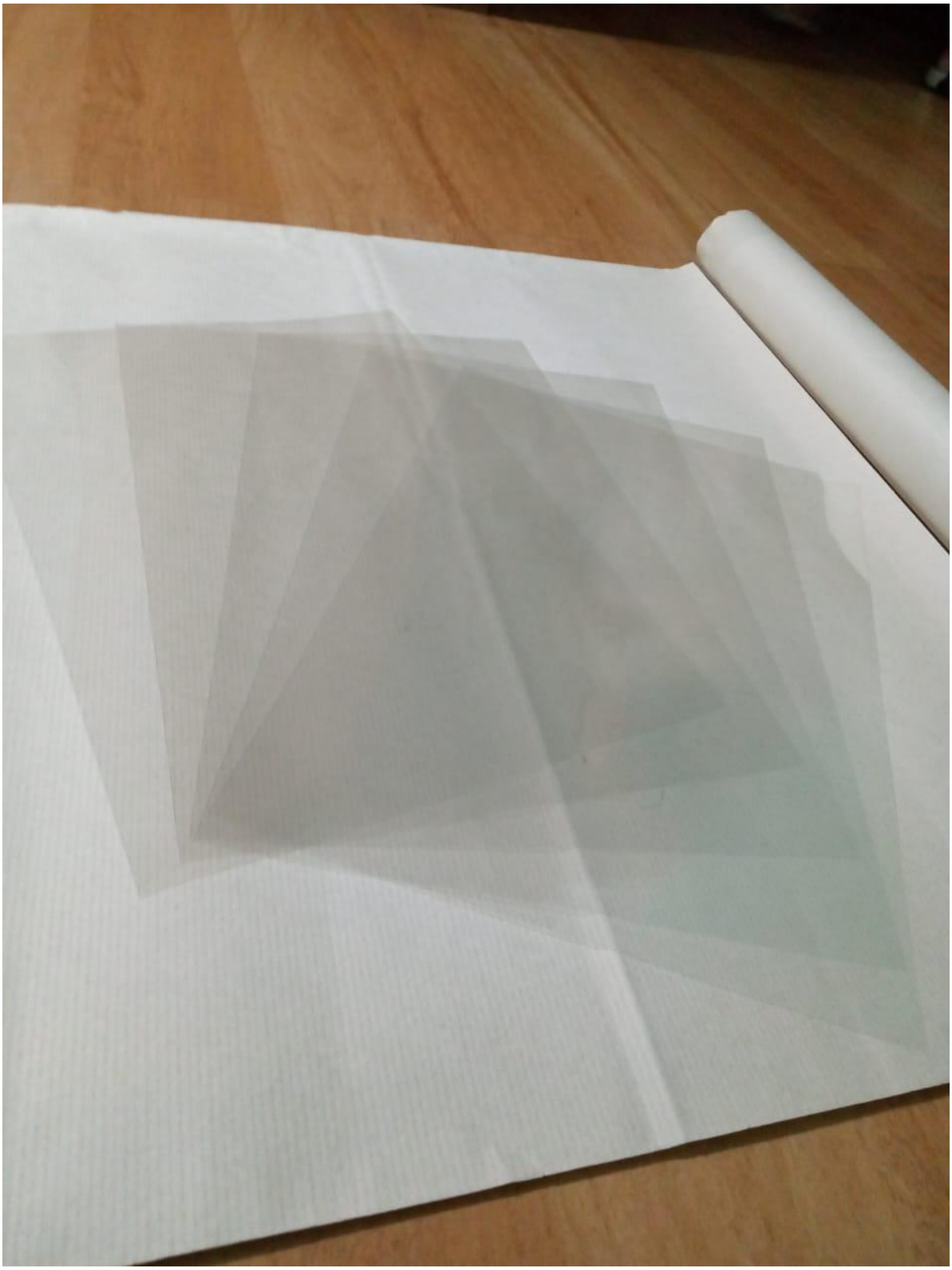
Black thread – Plate VIII

Black Velcro – Plate IX

Black zipper - Plate X

Pattern paper - Plate XI

OHP sheets - Plate XII

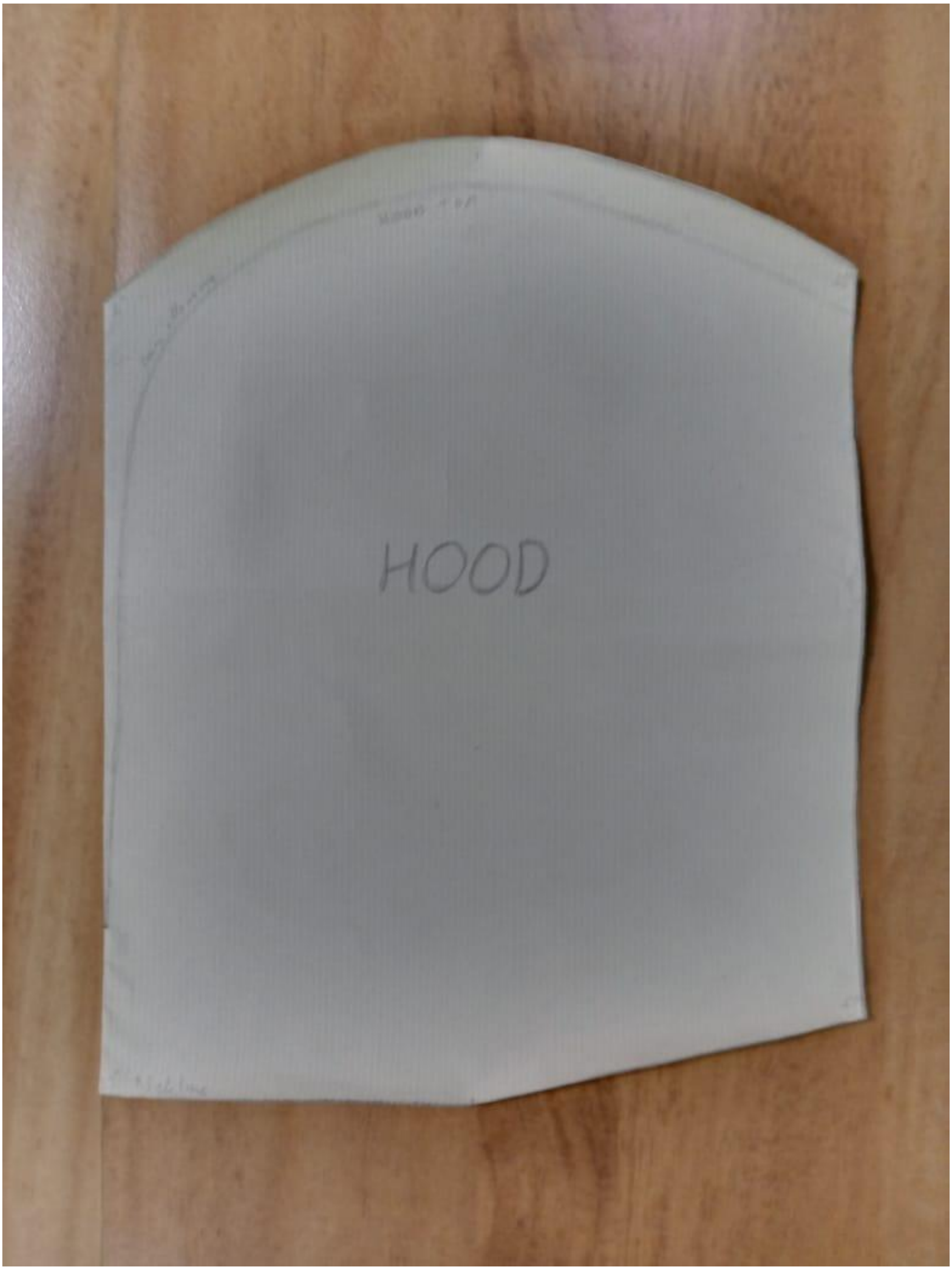


Front pattern - XIII

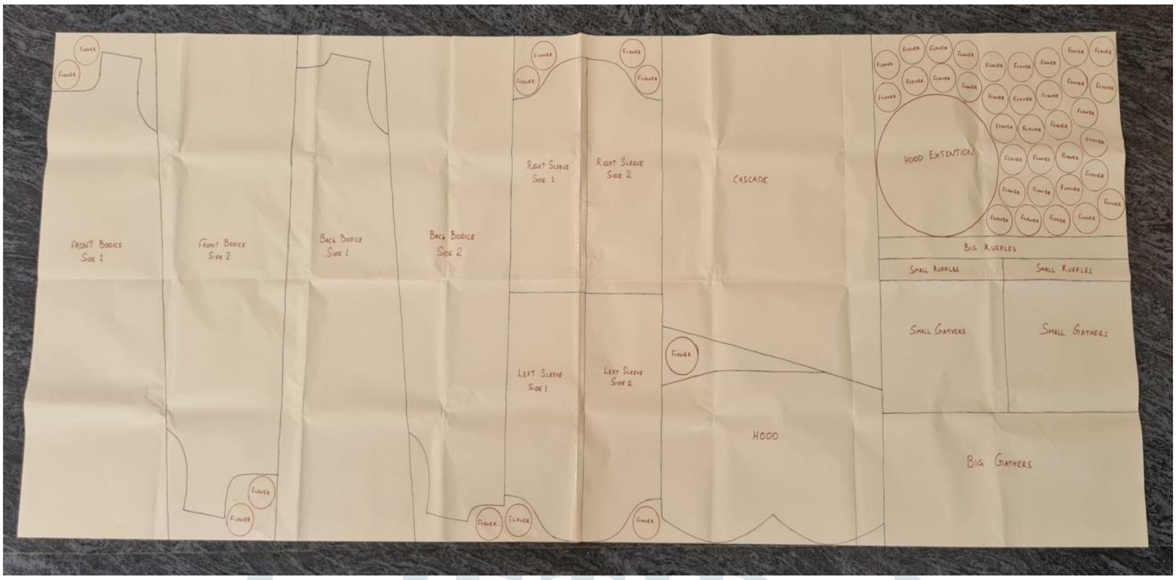
Back pattern – Plate XIV

Sleeve pattern – Plate XV

Hood pattern – XVI



Zero wastage method – Plate XVII



The above shown plate explains how a reversible designer rain wears are developed usingzero wastage method.

The packed arrangement shows, the fabric wastage is very less and the rest of the spaces areutilised to make carry pouches.

Fit test – Plate XVIII

Stencils for product 1 – Plate XIX

Stencils for product 2 - Plate XX

Stencils for product 3 - Plate XXI

Laying - Plate XXIV

Marker Making – Plate XXV

Cutting – Plate XXVI

Ink applying technique – Plate XXII

Spray test – Plate XXVIII

Waste extraction – Plate XXIII

Sewing - Plate XXVII

RESULTS AND DISCUSSIONS

This chapter refers to the result of the research procedures. All the aspects of result followedhave been divided into following sub headings:

4.1 Developed designs

4.2 Evaluated deigns

4.3 Collected raw materials

4.4 Prepared specification sheets

4.5 Prepared patterns

4.6 Prepared fit sample

4.7 Prepared stencils

4.8 Applied inks

4.9 Extracted waste fabrics

4.10 Developed products

4.11 Tested products

4.12 Prepared cost sheet

4.13 Evaluated products

4.1 Developed designs

The designs are developed by hand sketching using HB pencils and water colours.

4.2 Evaluated designs

The designs developed was evaluated based on the appearance, colour, design usability,shape/size and functionality.

Evaluations for design 1, evaluation for design 2 and evaluation for design 3 (Figure 1,2 and3).

4.3 Collected raw materials

Hydrophobic black fabric (polyester), Plastic sheet, Hydrochromic inks (blue, yellow andpink), Trims (thread, velcro and zipper), Pattern paper and OHP sheets are collected.

4.4 Prepared specification sheets

The specification sheets or spec sheets have been created for all the three prodcuts includingevery details of the products.

Specification sheet for product 1, specification sheet for product 2 and specification sheet forproduct 3 (Figure 4, 5 and 6).

4.5 Prepared patterns

The patterns for constructing the product was prepared using pattern paper.

4.6 Prepared fit sample

A fit sample is been developed to check whether the given measurements are correct or notsince the garment is a customised designer wear.

4.7 Prepared stencils

The stencils for applying inks on the fabric was prepared using OHP sheets.

4.8 Applied inks

The inks were applied using screen printing technique with the help of stencils.

4.9 Extracted waste fabrics

The fabric pieces are extracted from the waste cut pieces.

4.10 Developed products

Three reversible and colour enhancing or highlighting designer rain wears are developed forgirls in zero wastage (Plate XXIX, XXX, XXXI, XXXII, XXXIII and XXXIV).

4.11 Tested products

The developed products are undergone two different testing methods. They are Spray test forthe inks (Table 1) and Fit test for the size.

4.12 Developed cost sheet

A cost sheet have been developed to calculate the overall expense needed to create thegarment.

Cost sheet (Figure 7).

4.13 Evaluated products

The product developed was evaluated based on the appearance, colour, design usability,construction, texture, shape/size, finishing and functionality.

of product 1, evaluation of product 2 and evaluation of product 3 (Figure 8, 9 and10).

Product 1 in dry form - Plate XXIX

Product 1 when wet - Plate XXX

Product 2 in dry form - Plate XXXI

Product 2 when wet - Plate XXXII

Product 3 in dry form - Plate XXXIII

Product 3 when wet - Plate XXXIV

Figure 4 : Specification sheet of product 1

SPECIFICATION SHEET

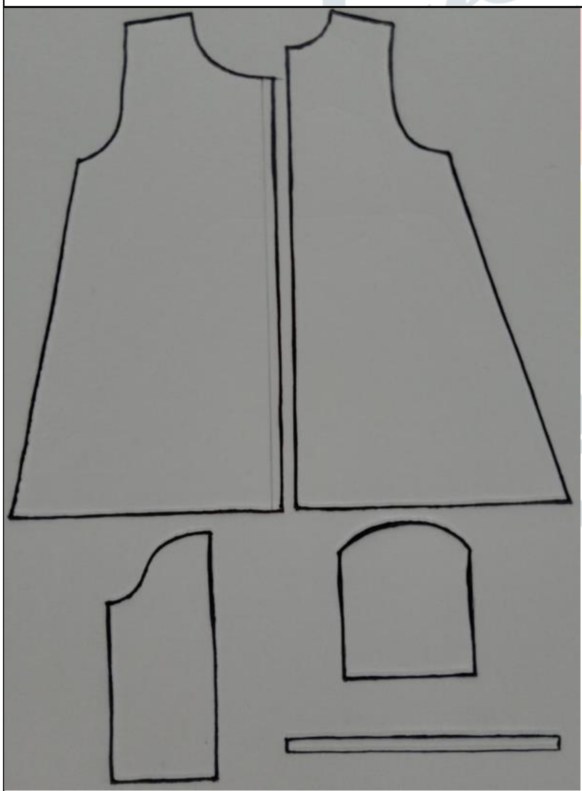
Style No: SS001	**Date:** 31/03/2023
Category: Girls rain wear	**Designer Name:** Sahla Shamsuddin
Size: 4-5 yrs	**Material Used:** Hydrophobic nylon

Description

Reversible raincoat with ruffles, 1 side depicts rain drops and other side depicts leaves.

SI No	Body parts	Measurements in inches
1	Full length	34”
2	Back neck	2”
3	Front neck	3”
4	Chest	6”
5	Shoulders	11”
6	Across chest	23”
7	Armhole	11”
8	Sleeve length	17”
9	Head length	9”
10	Head round	20”

Patterns

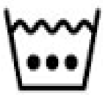


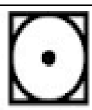
Fabric Swatch

Colours

Hydrophobic nylon	Black
Hydrochromic ink 1	Blue
Hydrochromic ink 2	Yellow

Product Care





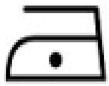


Figure 5 : Specification sheet of product 2

SPECIFICATION SHEET

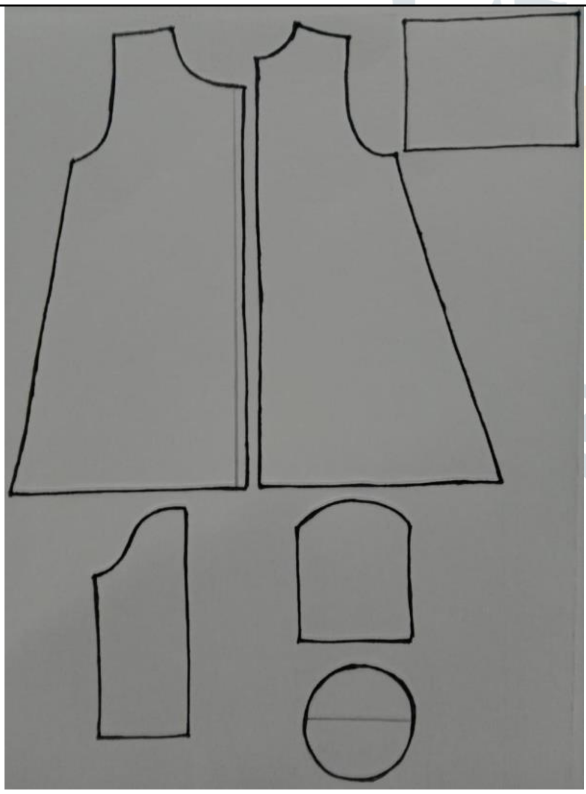
Style No: SS002	**Date:** 31/03/2023
Category: Girls rain wear	**Designer Name:** Sahla Shamsuddin
Size: 4-5 yrs	**Material Used:** Hydrophobic nylon

Description

Reversible raincoat with gathers, 1 side depicts coconut trees and other side depicts flowers.

SI No	Body parts	Measurements in inches
1	Full length	34”
2	Back neck	2”
3	Front neck	3”
4	Chest	6”
5	Shoulders	11”
6	Across chest	23”
7	Armhole	11”
8	Sleeve length	17”
9	Head length	9”
10	Head round	20”

Patterns



Fabric Swatch

Colours

Hydrophobic nylon	Black
Hydrochromic ink 1	Yellow
Hydrochromic ink 2	Pink

Product Care

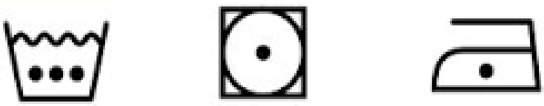


Figure 6 : Specification sheet of product 3

SPECIFICATION SHEET

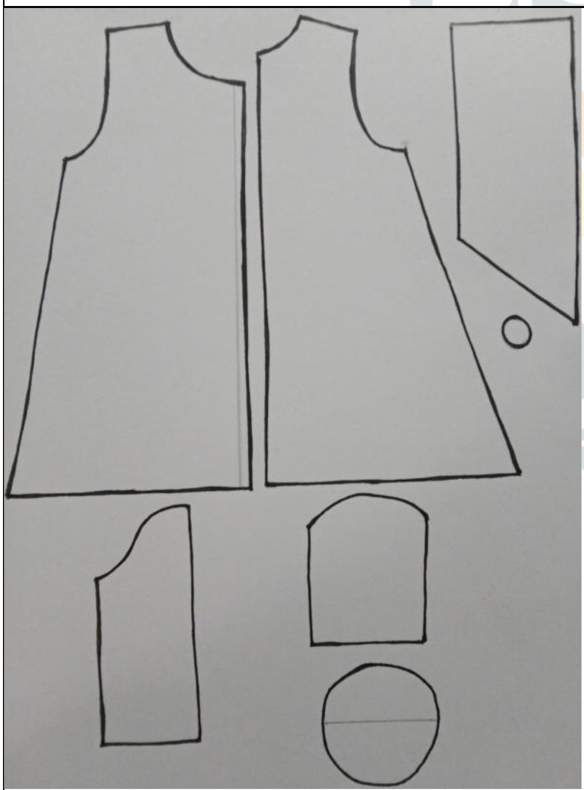
Style No: SS003	**Date:** 31/03/2023
Category: Girls rain wear	**Designer Name:** Sahla Shamsuddin
Size: 4-5 yrs	**Material Used:** Hydrophobic nylon

Description

Reversible raincoat, 1 side depicts waterfall with cascade and other side depicts flowers.

SI No	Body parts	Measurements in inches
1	Full length	34”
2	Back neck	2”
3	Front neck	3”
4	Chest	6”
5	Shoulders	11”
6	Across chest	23”
7	Armhole	11”
8	Sleeve length	17”
9	Head length	9”
10	Head round	20”

Patterns



Fabric Swatch

Colours

Hydrophobic nylon	Black
Hydrochromic ink 1	Blue
Hydrochromic ink 2	Pink

Product Care

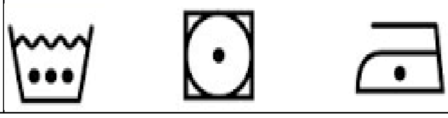
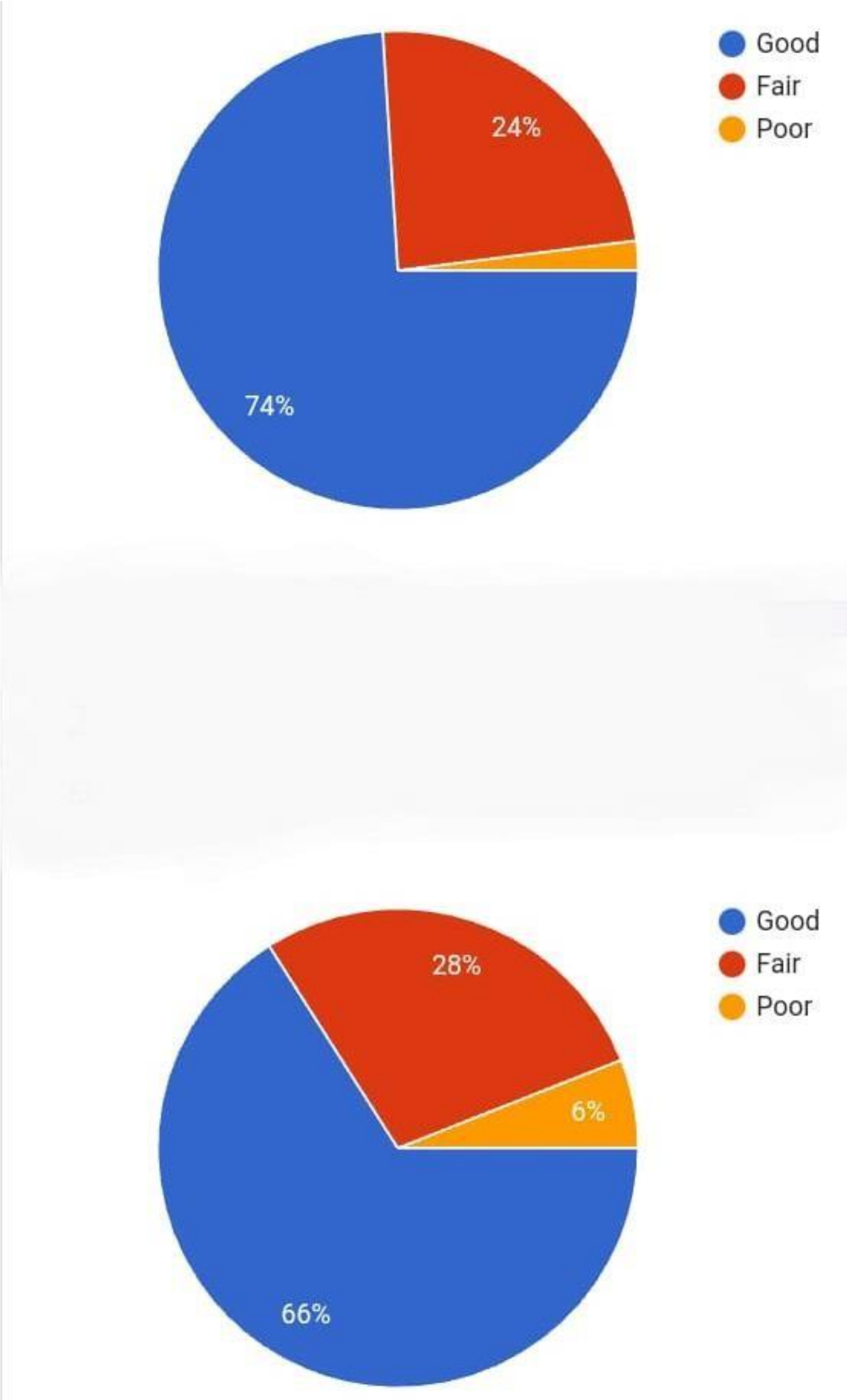
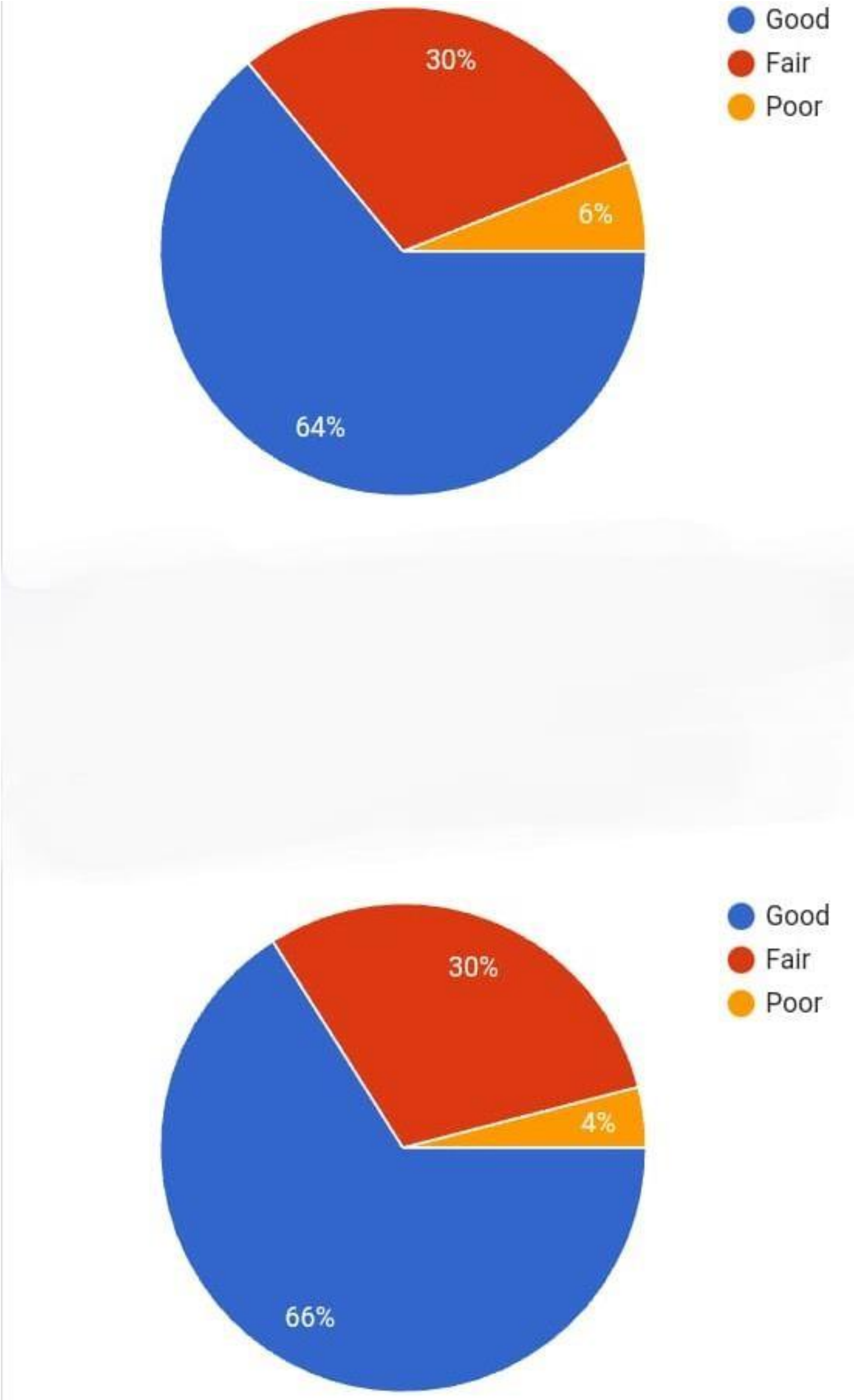


Figure 1 : Evaluations of design 1



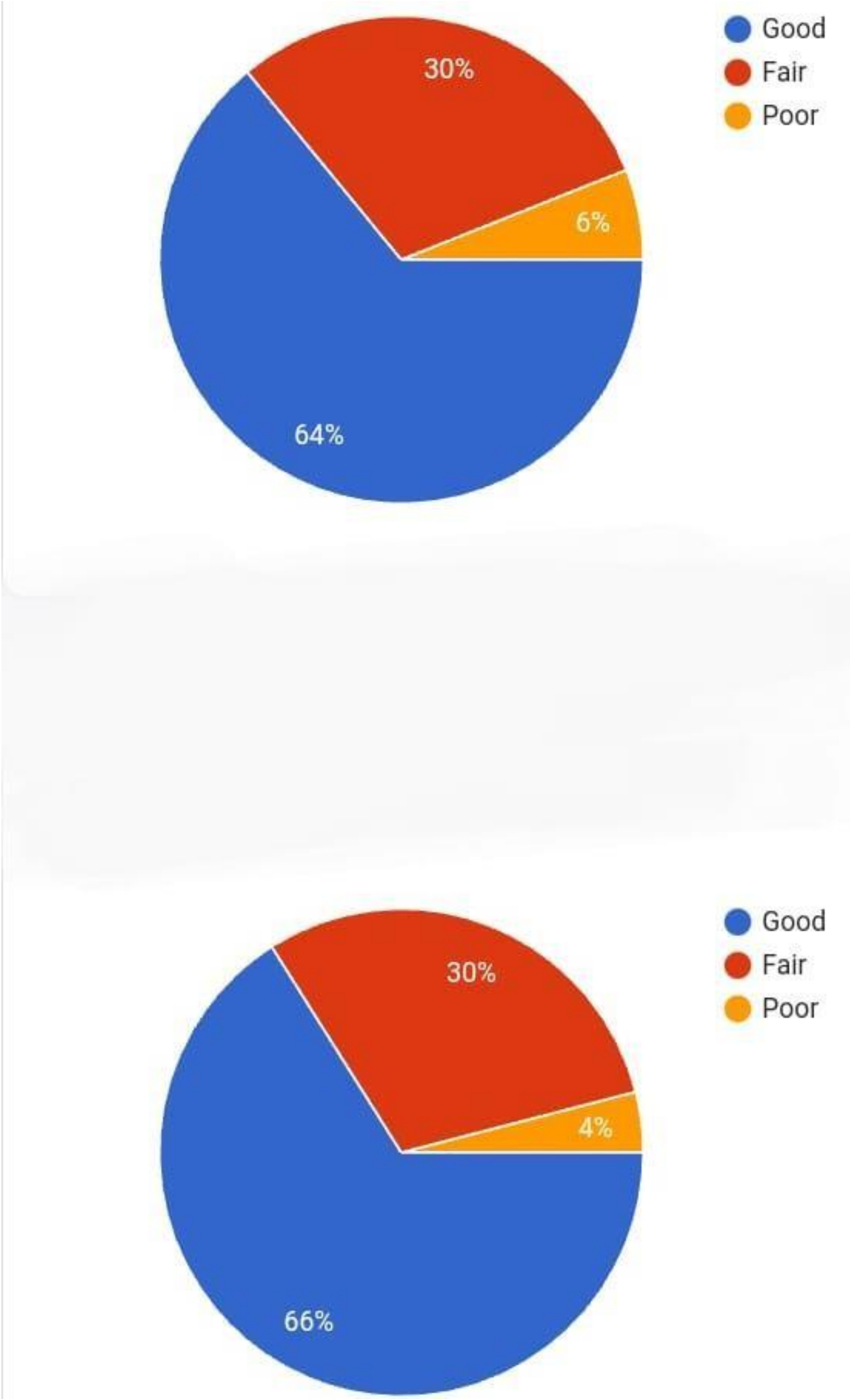
From the above pie chart diagrams, it is clear that, for design 1, the best rated parameters aregood (74% and 66%) and least rated parameters are poor (2% and 6 %). The category selected for the survey to evaluate the designs are Mothers since these are kids wear.

Figure 2 : Evaluations of design 2



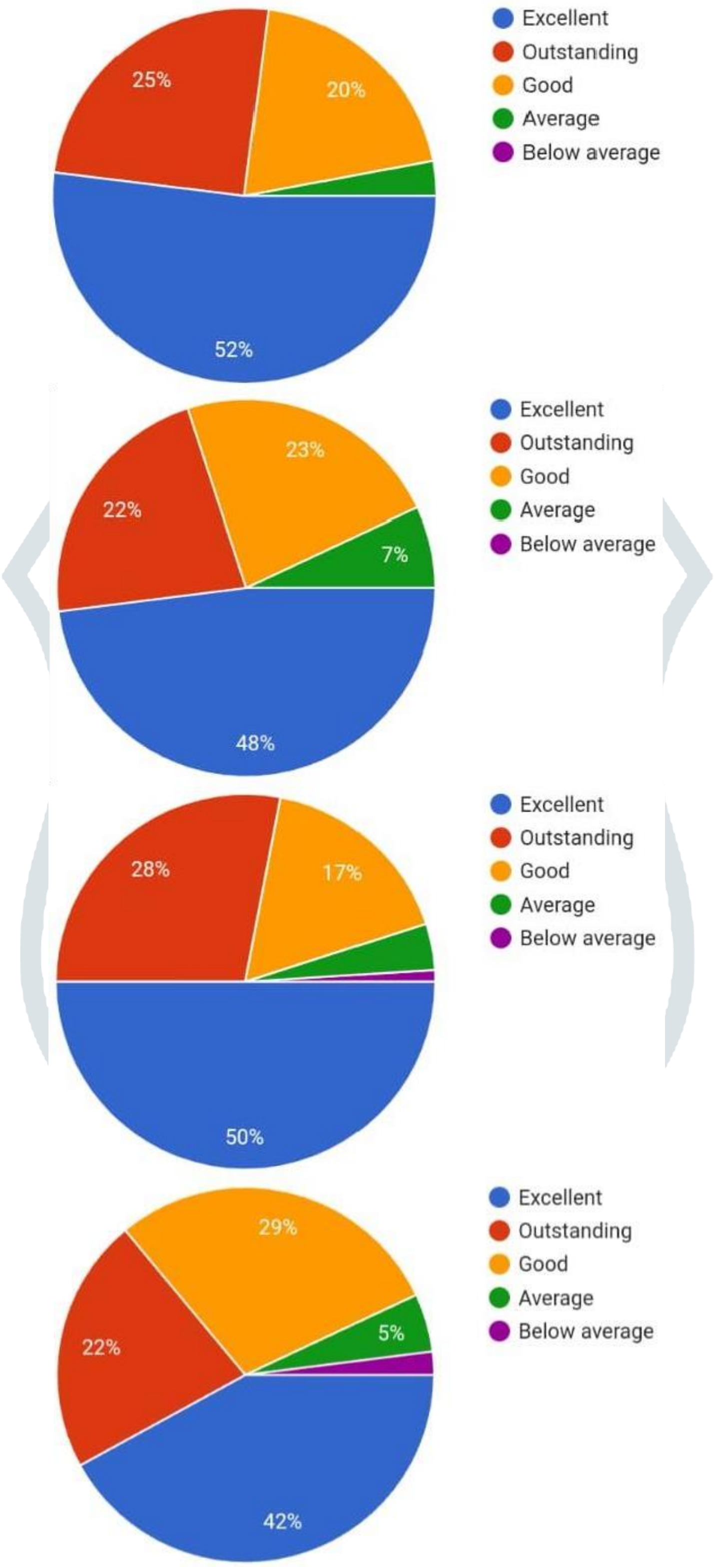
From the above pie chart diagrams, it is clear that, for design 2, the rated parameters are good(64% and 66%) and least rated parameters are poor (6% and 4%). The category selected for the survey to evaluate the designs are Mothers since these are kids wear.

Figure 3 : Evaluations of design 3



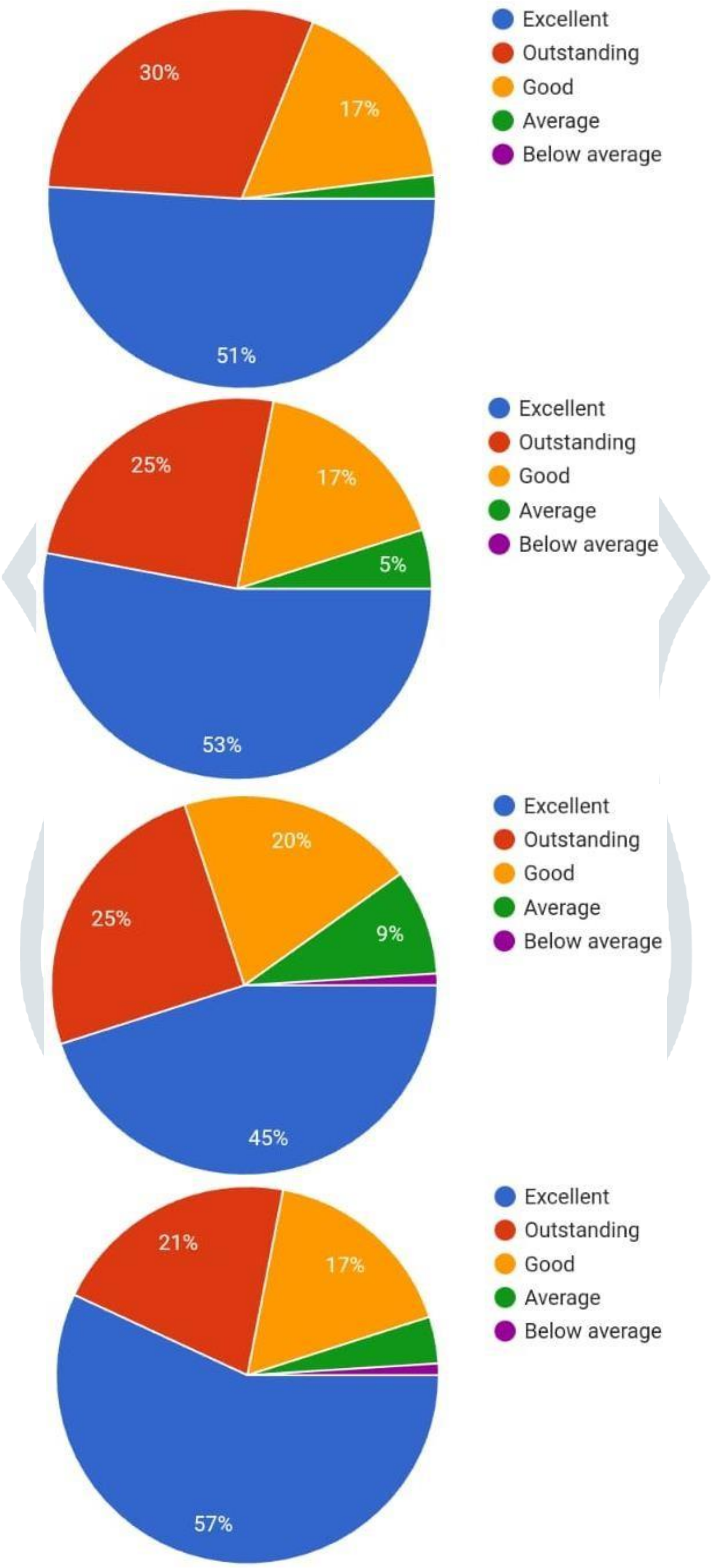
From the above pie chart diagrams, it is clear that, for design 1, the best rated parameters aregood (64% and 66%) and least rated parameters are poor (6% and 4 %). The category selected for the survey to evaluate the designs are Mothers since these are kids wear.

Figure 8 : Evaluations of Product 1



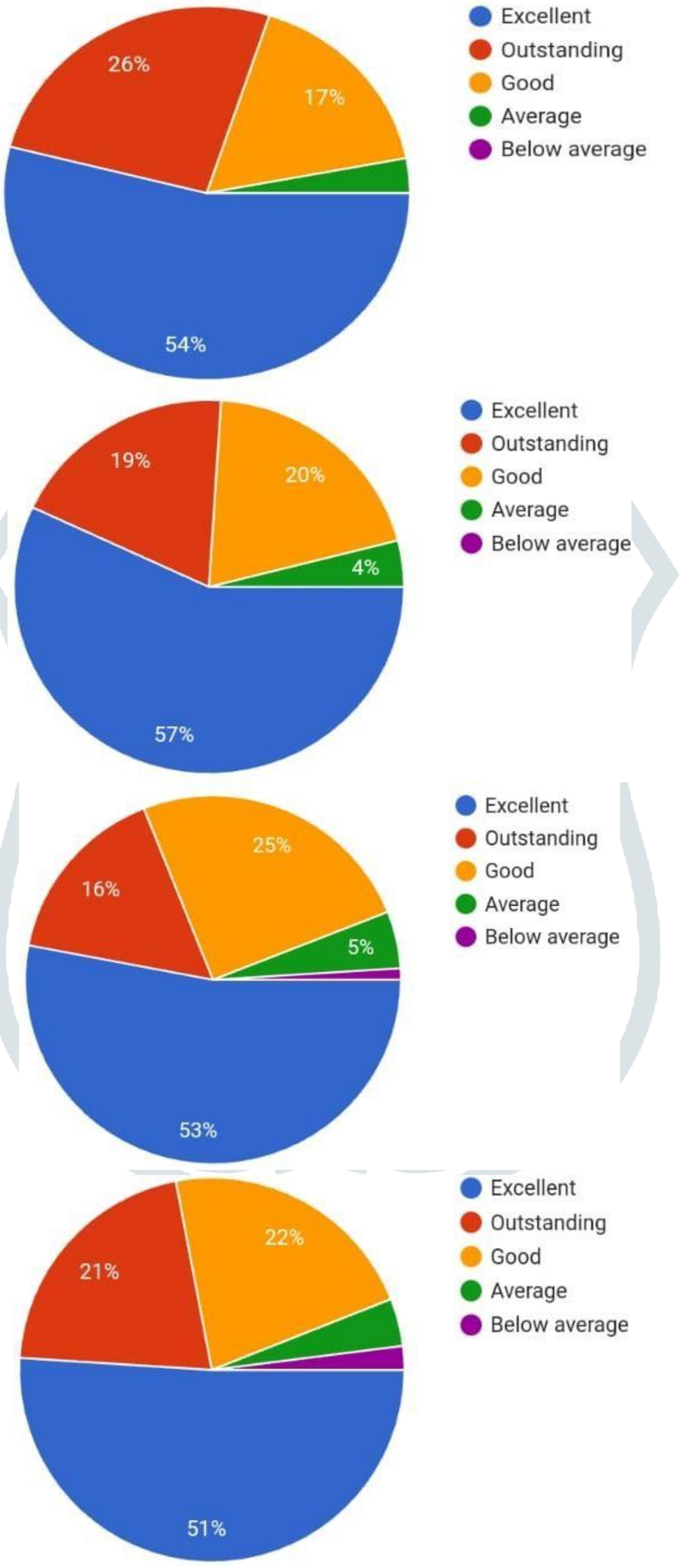
From the above pie chart diagrams, it is clear that, for product 1, the best rated parameters areexcellent (52%, 48%, 50% and 42%) and least rated parameters are below average (1% and 2%). The category selected for the survey to evaluate the products are Mothers since these arekids wear.

Figure 9 : Evaluations of Product 2



From the above pie chart diagrams, it is clear that, for product 2, the best rated parameters areexcellent (51%, 53%, 45% and 57%) and least rated parameters are below average (1% and 1%). The category selected for the survey to evaluate the designs are Mothers since these are kids wear

Figure 10 : Evaluations of product 3



From the above pie chart diagrams, it is clear that, for product 3, the best rated parameters areexcellent (54%, 57%, 53% and 51%) and least rated parameters are below average (1% and 2%). The category selected for the survey to evaluate the designs are Mothers since these are kids wear.

Table 4 : Spray test

SI No	Sample	Standard spray test rate
1	1	5
2	2	5
3	3	5

From the table, it is clear that the mean of rating of the fabric is 5.Therefore, the standard spray test rating of the fabric is also 5.

Figure 7 : Cost sheet

Style No : SS001	**Date :** 31/3/3023
Category : Girls rain wear	**Designer Name :** Sahla Shamsuddin
Size : 4-5 yrs	**Material Used :** Hydrophobic Nylon
Direct cost : 643/-	**Indirect cost : 432/-**
Profit : 20%	**Total cost : 1290/-**

Direct cost	**Indirect cost**
Hydrophobic nylon – 296/-	Labour – 136/-
Plastic sheet – 69/-	Electricity – 109/-
Hydrochromic inks – 203/-	Transportation – 187/-
Black thread – 10/-	**Profit**
Black Velcro – 20/-	215/-
Pattern paper – 30/-	**Total price**
OHP sheet – 15/-	1290/-

This is a cost sheet for a single garment. The distribution and arrangement of costing forother two garments are also in the same pattern mentioned above in the figure 7.

SUMMARY AND CONCLUSION

Hydrophobic fabrics resists water penetration with extremely low absorbency and high stability, these are used for products that are intended to provide a dry barrier, while withstanding moisture. Hydrophobic polyester fabric is used to develop various styles of rain coats with carry pouch for kids.

Hydrochromic inks are used to produce prints or coatings which change colour when exposedto water, the ink dries to a coloured film, the strong colour and opacity disappears on contact with water. Various coloured hydrochromic inks are applied on the rain coats with nature based themes using stencils on it.

A reversible garment is a garment that can be worn two ways, which differ by turning the garment "inside out", however there i no true "inside out" to a reversible garment, since either way, it gives a fashionable appearance. These rain wears can also be worn in two ways,hence these rain wears are reversible and fashionable designer rain wears.

Zero waste fashion refers to items of clothing that generate little or no textile waste in their production. It can be considered to be a part of the broader Sustainable fashion movement. These rain wears are developed in zero wastage method, hence these rain wears helps in Sustainable fashion movement.

The present study is focused on the development of reversible designer rain wears in zero wastage and applying hydrochromic inks on hydrophobic fabric. The hydrochromic inks wereapplied and dried under the fan. The result shows that it is acceptable and was ranging between excellent and good. According to the evaluation conducted product 1 got the highest and product 3 got the lowest score.

From the above mentioned evaluation diagrams, it is clear that, the best rated product among the total three products is Product 3 (53.75%) and the least rated product among the total three products is Product 1 (48%).

RECOMMENDATION AND SUGGESTION

- This type of designer rain wears can be applied for men, women, and boys alsoinstead of girls.
- The colour of the ink and fabric can be chosen differently to get a different outlookfor the wearer.
- The patterns of the designs can also be changed according to one's wish to make thedesigner wear look more beautiful.

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APPENDICES

Appendix no: 1 Product 1 in dry form

Appendix no: 2 Product 1 when wet

Appendix no: 3 Product 2 in dry form

Appendix no: 4 Product 2 when wet

Appendix no: 5 Product 3 in dry form

Appendix no: 6 Product 3 when wet