PRECIOUS CUT:

A PRACTICE-BASED RESEARCH TOWARD ZERO_WASTE DESIGN BY EXPLORING CREATIVE PATTERN CUTTING METHODS AND DRAPING TECHNIQUES

by

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ABSTRACT

With the contemporary methods of fashion construction only effectively using 85 percent of fabric in a garment, 15 percent of the total fabric is left on the cutting room floor. This waste is leaving a “significant ecological footprint”. This thesis is practice-based research to explore creative pattern cutting methods and draping techniques which lead to zero-waste designed garments. This thesis also demonstrates how pre-industrial societies treated fabric as a precious source, utilizing every piece of fabric to minimize waste. The environmental and ethical impact of producing textiles and why we should avoid the wasting of fabric are discussed. Investigations of different ways that fabric waste can be eliminated in the modern fashion industry and various methodological approaches toward zero-waste are examined: Jigsaw with fixed area, Jigsaw with the full width of fabric and tessellation. A new approach, Transformational Reconstruction, which is an innovative patternmaking technique developed by a Japanese designer - Shingo Sato, is examined and tested for its usefulness for zero-waste design. This study proposes that the fashion designer and pattern-cutter can have a great influence on the amount of fabric waste and, working as a team, are capable of producing garments without fabric waste and reducing the ecological footprint of modern apparel production.

DEDICATION

To my dear husband **Behrouz Khodadadi** for his everlasting encouragement, love and support

To my parents **Esmaeil Saeidi** and **Shahla Mardani** who sacrificed their today for my tomorrow

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INTRODUCTION

Why Change?

During the preparation for a fashion show in Spring 2014, leftover fabrics from garments were accumulating in my locker, which made it difficult to open. At that time, I decided to create an environmentally friendly garment with all these leftover fabric cuts, using all the scraps. Although my goal was to make an environmentally friendly garment, there were still scraps of fabric on the cutting room floor after construction. Therefore, I saw the reasoning behind the quote "it's better to prevent waste than to treat or cleanup waste after it is formed" (Anastas and Zimmerman, 2003, p. 96A). This was the first foray of my design journey to create garments with zero-waste.

Textile waste is created in either pre-consumer or post-consumer stages of a garment's lifecycle. Pre-consumer textile waste consists of wastage of fiber, yarn, fabric, and garments during manufacturing. Post-consumer textile waste is created by consumers, which may consist of any type of garment or household item that has become unnecessary (Hawley, 2006). This study is concerned with pre-consumer textile waste and, more specifically, the waste created during the design and cutting processes.

Traditionally garments do not exist without fabric or textile. I agree with Rissanen that "Fabric is precious" (Rissanen, 2008, p. 184) and fashion should respect it. With the contemporary methods of fashion construction only effectively using 85 percent of fabric in a garment, 15 percent of the total fabric is left on the cutting room floor (McQuillan, 2011). This waste is leaving a "significant ecological footprint" (Rissanen, 2008, p. 184).

Fabric waste for adult outerwear varies on average from 10 to 20 percent, with the estimation of 10 percent for trousers or pants and greater percentages for blouses, jackets, and underwear (Rissanen, 2013). As is illustrated in Figure 1 pattern pieces have irregular shapes, which make them impossible to interlock perfectly to use 100 percent of fabric length and width. In other words, the amount of fabric waste depends on how the pieces can interlock on a fabric spread.

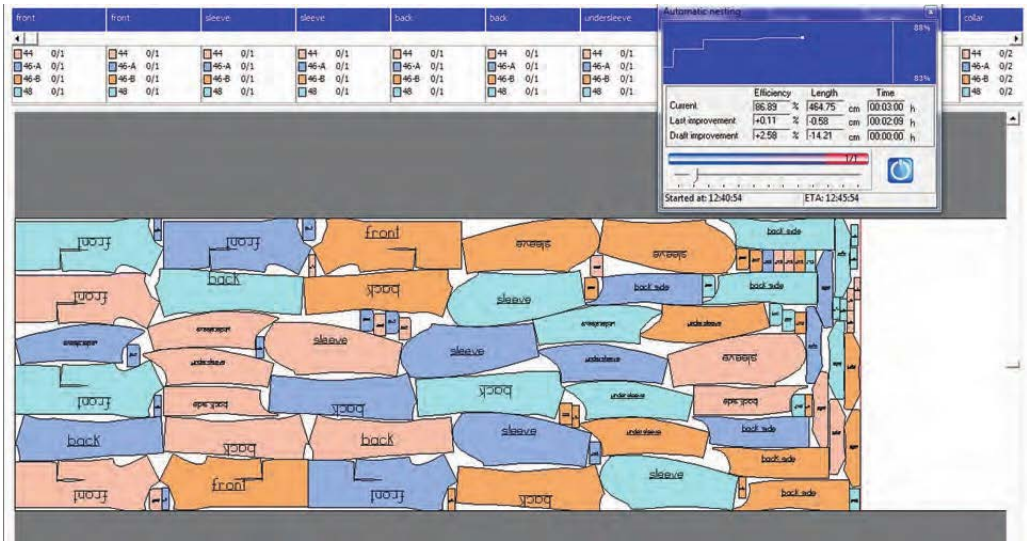

Figure 1: Fabric waste in cutting process, Rissanen (2013)

This thesis is practice-based research to explore creative pattern cutting methods and draping techniques which lead to zero-waste design garments. The study proposes that the fashion designer, marker maker and pattern cutter can have a great influence on the amount of fabric waste and may be capable of producing garments without fabric waste. It will be demonstrated how pre-industrial societies treated fabric as a precious resource and how they valued fabric by utilizing every piece of fabric to minimize waste. The environmental and ethical impact of producing textiles and why we should avoid wasting fabric will be discussed here. Finally, investigations of different techniques for fabric waste

elimination in the modern fashion industry and various approaches toward zero-waste will be examined.

CHAPTER 2

REVIEW OF LITERATURE

”Fashion designers often regard fabric as their raw material, but fabric really is a finished product in its own right”

Timo Rissanen (2005, p.7).

Introduction to the Problem

Prior to recent improvements in technology, exchange of information was not as fast as in the present. In the contemporary world, information and trends are transferring around the globe at a terrific speed. Advances in technology both in social and industrial environments have sped up the globalization of changes in clothing trends. The combination of the cheap production of both textiles and apparel along with the rapid distribution of fashion trends in the contemporary world has led the industry to respond to the changing whims of consumers through “fast fashion.” Once styles are revealed on the catwalks and internet, fast fashion firms, such as Zara, H&M, Mango, New Look, and Top Shop, can offer apparel in a minimum of three to five weeks from design room to retail stores (Bhardwaj and Fairhurst, 2010).

According to Claudio (2007), “’Fast fashion’, the clothing equivalent of fast food” provides affordable apparel in the marketplace with the aim of tempting consumers to purchase more in order to have the latest styles and remain up to date (p. A449). McQuillan (2011) describes fast food as a successful, convenient, and cheap market because no arrangement for cooking food and buying ingredients is needed. However, the

environmental impact of food production and also the effect of food consumption on the human health do not appear in the final price. McQuillan (2011) generalizes that convenient and low cost fast food is similar to fast fashion, with both carrying huge environmental and social impacts. Therefore, reducing the environmental effects of fast fashion is important because according to Ericson's evaluations, "the garment industry is responsible for 7 percent of world carbon emissions," which includes the transportation of leftover fabrics to landfills (2010, p.62).

Transportation to and disposal of fabric with in landfills is problematic. With the estimation of 15 percent fabric waste for an adult size garment (Rissanen, 2005; Cooklin, 1997) and 1 million tons of clothing consumption in United Kingdom, Timo Rissanen (2008) estimates that 100,000 tons of fabric is wasted to make clothes annually. Several stages of the fiber to fabric process are also ecologically problematic; therefore, environmental consideration is the principle motivation for eliminating fabric waste. Designers need to be aware of the environmental impact of various processes in textile production and try to use the fabric efficiently.

Why We Should Eliminate Fabric Waste?

With the advancements in the textile industry and new technologies in fabric production, the cost of fabrics is becoming increasingly more economical; thus, the amount of fabric waste may not seem worth worrying about for both designers and manufacturers. According to Fletcher (2008) "cotton and polyester together account for over 80 per cent of the global market in textiles" (p.4); consequently, their influences are significant. By

reviewing the processing of cotton from fiber to fabric, one of the most popular and versatile clothing fibers, some environmental aspects will be revealed.

Cotton as a natural fiber is mistaken for an environmentally friendly fiber and many ecologically sensitive consumers consider it as a good choice (Kadolph, 2007). Although cotton is a renewable and biodegradable resource, it cannot be produced without an environmental footprint. The total area of cotton farmland world-wide has stayed the same during the last 80 years, but the amount of cotton product has been tripled as a result of using large quantities of fertilizer and pesticides, since cotton plants are highly susceptible to insect damage and soil depletion (Fletcher, 2008). It is estimated that cotton uses 2.4 percent of the world's arable land while cotton production involves 24 percent of insecticides and 11 percent of pesticides of the global market (Chapagain et al., 2005) and "the Unites States is the predominant user of these pesticides and insecticides" (Chen & Burns, 2006, p.250). Large amounts of pesticides and insecticides in cotton production contaminate ground water and surface water due to the release of nutrients and pesticides from the plant root (Chapagain et al., 2005). Also disturbed are the aquatic ecosystems as the nitrate pollution to water expedites the growth of aquatic plants, which results in lack of oxygen for the typical animal life (Fletcher, 2008). Heavy use of pesticides also has severe health impacts on workers in the field and nearby populations.

Cotton is a thirsty fiber requiring heavy irrigation, which can cause dramatic changes in local water resource balances. About 50 percent of the global cotton fields are rain-fed not irrigated; the Aral Sea is the most famous example for the effect of water reduction available for irrigation (Fletcher, 2008). Cotton growing and processing accounts for 2.4 percent of the global water use (Chapagain et al., 2005). Further, a large quantity of

water, chemicals, and energy is consumed in the cleaning of fibers and in the dyeing and finishing of the fabric.

According to Cooklin (1997), in conventional fashion design approximately 15 percent of the total fabric is wasted. The annual consumption of clothing in the United Kingdom, for example, is estimated about 1 million tons annually (Rissanen, 2008). With the conservative estimate of fabric wastage (10 percent), that means 100,000 tons of fabric are wasted annually to produce the annual clothing consumption of the United Kingdom. According to Fletcher (2008), 40 percent of all clothing worldwide is produced out of cotton and 8000 liters of water is required to produce 1 kg of cotton fiber; therefore, a simple calculation reveals that 320 million liters of water are wasted during cotton fiber production.

Fletcher (2008) and Rissanen (2013) discuss that when fabric is being wasted in the production process, it also can be concluded that the embodied energy and economic investment in the fabric production is also being wasted. While there is embodied energy for the production of the fiber, the energy embodied during the production of the fabric is greater. This embodied energy is the total energy that was consumed to bring the textile into its existing form. This total energy includes: the energy of accumulating the raw material, human labor for acquisition and processing, mechanized processing of the whole sequence, water utilized for transformation of fiber into yarn and then fabric, and finally, the transportation involved between different stages. Fabric as a finished product embodies the time and effort of all the people who contribute to fiber into fabric process; therefore, wasting a percentage of the fabric is also wasting the embodied effort of all those individual contributions. Further the wasting of fabric during design and cutting processes also make

the environmental impacts caused in cloth production even greater. In fact with wasting of fabric "… a 'hidden history' of industrial processes that mine, divert, extract, shovel, waste, pump and dispose of billions of kilos of natural resources in order to produce and deliver the fabric that is destined to fall to the cutting-room floor" (Fletcher & Grose, 2012).

Historical and Contemporary Zero-Waste Design

In order to design innovative garments that meet the goal of this study, which is designing zero waste garments, it was also necessary to study both historical and traditional garments throughout history for efficient fabric utilization. Therefore, the researcher reviewed the evolution of zero waste and low waste garments from before and after the Industrial Revolution, in order to apply this knowledge to the current study.

During the Pre-Industrial Revolution period, production of textiles and garments was time consuming; therefore, fabrics were treated as a precious source and Pre-Industrial Societies tried to use every cut piece, which sometimes resulted in using 100 percent of the fabric (Burnham, 1973). After the Industrial Revolution, the textile industry improved through new technologies being used in producing textiles with the result that some fabrics become so inexpensive that the amount of waste was not regarded as problematic or of concern.

The zero waste approach is not a new concept. Patterns, taken from historical clothing, show that less fabric was wasted in the process of making fashionable garments. Indigenous clothing and traditional dress are examples of zero waste design concepts because "cloth was clothing itself" (Rudofsky, 1947, p.143). Burnham (1973) also states "the simplest garments are those with no cutting or sewing at all" (p.4). The peplos and

Ionic chiton of ancient Greece are pieces of cloth draped around the body without being cut or stitched; therefore, none is wasted (Rudofsky 1947). See Figure 2, which is an example of the Ionic chiton. The Indian sari is another example of a length of cloth that can be draped in a variety of ways (Carrico & Kim, 2013). The length and width of the sari varies between regions but remains uncut in use (Lynton, 1995). The Japanese kimono is another example of a zero waste traditional garment. No waste is created in the cutting process; all pieces of the garment are dictated to the width and length of the traditional Japanese cloth. An individual's height determines the length of the garment and fitting is adjusted with a tuck rather than further cutting (Dalby, 1993, p. 20).

Figure 2: Greek Sculpture, 5th century B.C.
Cloth was clothing

Approaches toward zero-waste were not limited to traditional garments such as the sari, which is uncut and wrapped around the body, and the kimono that made use of every cut piece and was adjusted for fit with tucks. European tailors and dressmakers centuries back tried to eliminate fabric waste in the cutting process and pattern development (Tarrant, 1994). Hill and Bucknell (1967) state that before the 1800s, The width of the fabric and its

costs dictated the way of the cutting, therefore, most of the time patterns were closely interlocked and had negligible cut-offs to use fabric efficiently.

Deborah Burnham (1974) in her book, *Cut my Cote,* discusses various factors that influence cut and shape of the garment. Although the body is the first and constant variable in the development of the garment, climate, geographical terrain, social status, and modesty are dynamic variables that are of key importance and have their effect on the shaping of the garment, Burnham states “the material from which a garment is made is the factor that has the most influence on the particular shaping of it” (p.2). Burnham claims that developments in cutting garments based on the two separate factors that ultimately merged into one: “cut based on the shape of the animal skin, and those dependent on the rectilinear form of the loom-woven cloth” (p.2).

Burnham (1974) provided the comprehensive documentation and diagrams of the cuts of garments in the Royal Ontario Museum that indicated the zero waste and/or low waste of fabric. Burnham, in all her examples presented, showed the efficiency of cut and the amount of fabric waste in producing garments. For instance, the man’s shirt, thought to be Italian from the late 16th century (Figure 3), indicated the efficient use of fabric without waste. An Englishman’s shirt of early 19th century (Figure 4) is an example of minimal waste, made up of squares and rectangles and underarm gussets to provide movement. The woman’s 17th century shirt (Figure 5), thought to be Italian, is another example of low waste that is made with squares and rectangles and the shaping is achieved with gathering at the neck and wrist.

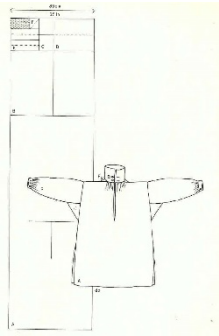

Figure 3: Late 16th century, man's shirt, probably Italian

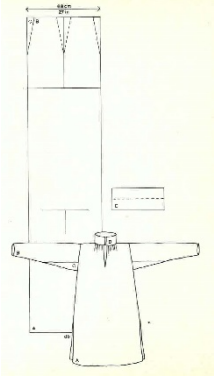

Figure 4: Early 19th century, man's shirt English

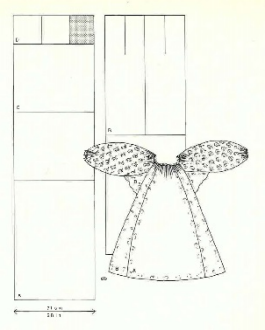

Figure 5: 17th century woman's shirt, probably Italian

Courtesy of the Royal Ontario Museum, © ROM

Tilke (1974) in his book *Costume patterns and designs* presents a detailed investigation of costumes of different peoples and eras, including some of them that could be considered low waste or zero-waste. For instance, the man's breeches from Turkey as seen in Figure 6 are constructed with two rectangles as the legs of the garment with some fabric cut away inside the ankle. The crotch is shaped with four gores. Figure 7 provides another example of men's kaftan from Middle East that is formed using triangles and rectangles with some fabric cut away around the sleeve wrist area.

Figure 6 : Men's breeches from Turkey by Tilke (1974)

Figure 7: Men's kaftan from Middle East by Tilke (1974)

In 1919-1920 the Italian futurist artist Ernesto Thayaht created the Tuta (Figure 8), a one-piece garment that could be worn at all occasions and anytime of the year. Design of the Tuta was based on the principle of comfort, simplicity, and hygiene. The outfit was cut as one piece and the triangle piece between the legs was used as a front facing. In the women's version the pants are substituted with a skirt (Stern, 2004). This simplicity of the Tuta resulted in the sale of 1000 patterns in a few days after its release (Stern, 2004).

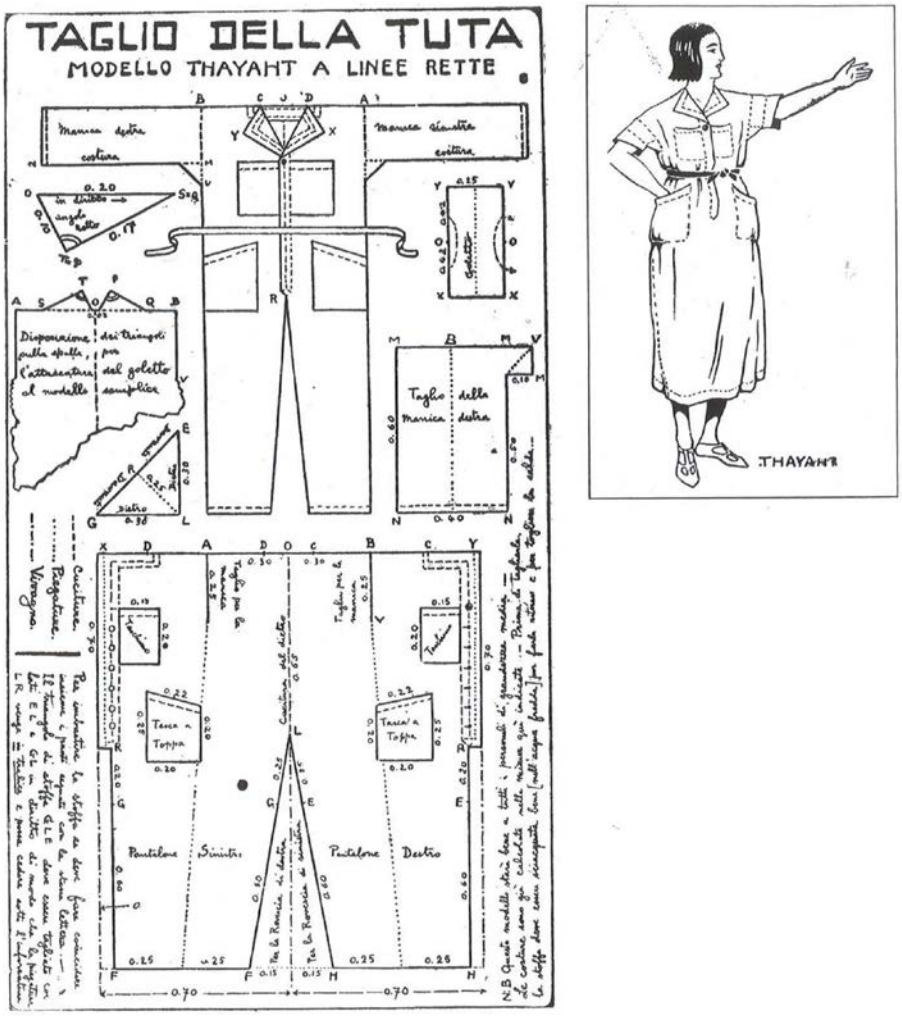

Figure 8: Tuta 1918-1919 by Ernesto Thayaht; woman's Tuta at right

From the early twentieth century, the zero waste approach began repeating. Rudofsky, who has criticized the contemporary fashion design in contrast to historical methods, noted the efficient use of fabric in making some garments, prior to Burnham (Figure 9). He criticized the wasteful methods of fabric cutting used by the Europeans in making clothes (Rissanen, 2013). At the exhibition, *Are Clothes Modern?* Rudofsky included some examples of no-waste garments by fashion designer Claire McCardell, as seen in Figure 10 (Rudofsky, 1947). She used two rectangles sewn together in her designs and fitting was achieved with elastic bands either at the shoulder, under the bust or the waist. As illustrated in Figure 11, her designs often were worn with belts. According to Rudofsky's description "these garments were made without cutting" (1947, p.203). He also noted that these garments were not experimental; they were designed for mass market and sold well.

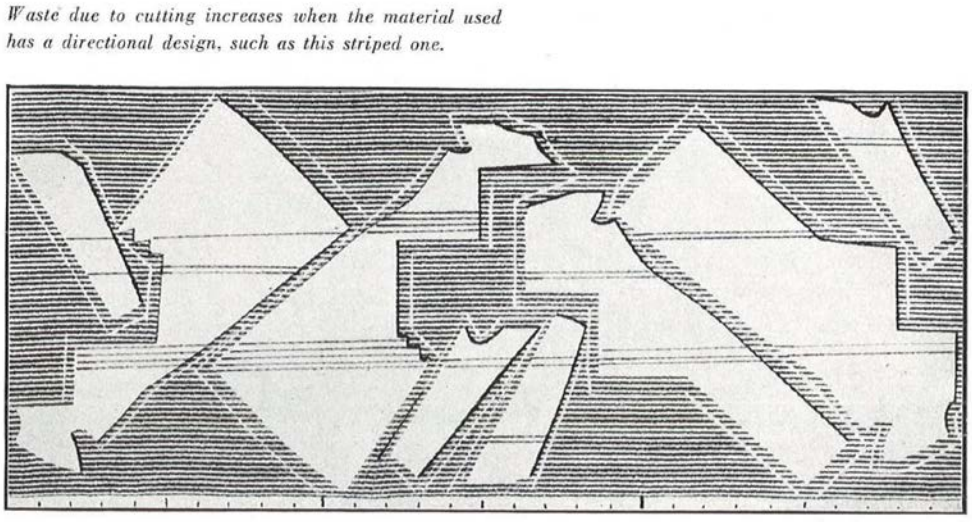

Figure 9: Highlighting waste due to using directional fabric by Rudofsky (1974)

Figure 10: Dress and Jacket made from rectangular pieces by Claire McCardell

Figure 11: Dresses and skirt made by seaming two rectangles;
Designer: Claire McCardell

In the 1950s Rudofsky applied his knowledge of historical garments in producing his women's collection, called *Bernardo Separates* (Figure 12). All the garments in his collection were created with rectangles and were the first garments produced industrially only in one size that fitted all, because shape was created with drawstrings or belts (Bocco Guarneri, 2003). According to Rudofsky, it was unnoticeable for most of the garments that their geometrically shaped patterns were different from conventional patterns until the garment was spread out flat. He also noted that by having minimum cuts and reducing machine work, the cost would be mainly of the material. The absence of the pockets and buttons made them easy to clean and the flat shape of the garments enable them to be folded and stored easily which saved space and kept the shape of the garments. In spite of all of the mentioned characteristics and reasonable price of the garments, sale of the garments was not successful and production soon ceased (Bocco Guarneri, 2003).

Figure 12: Bernard Rudofsky's separate collection

During the nineteenth century, fashionable Western clothing began to replace the traditional garments made of rectilinear pieces with more curvilinear pieces that utilized more fabric and created more waste. This change in styling accompanied the faster production of cloth enabled by the Industrial Revolution.

Another 20th century designer, Zandra Rhodes, who started designing in the 1970s and still is a contemporary textile and fashion designer. Rhodes designs the textile print prior to designing the garment. While other fashion designers may waste the embodied energy and time that a textile designer or a textile engineer puts into the design of the textile, it is not bearable for Rhodes to waste even an inch of her designed textile; as she states "I always consider what is left and try to make it into another part of the dress. I can't tolerate waste and use every inch," (Rhodes and Knight, 1984). To come up with an idea, Rhodes pins the printed fabric on herself in front of the mirror and lets the pattern determine the shape of the garment and its influence on the body. The wrap dress from 1979 (Figure 13), which is titled *Chinese Square,* is an obvious example that shows how the pattern of the textile led the design (Rhodes, 2005). Cutting around the hand painted squares makes the resulting garment very close to zero-waste, because the selvedges have been removed. YIELD, the catalog, describes this dress as "simple" in its construction yet "complex" in the pattern of the textile and its resultant intricate design. The dress is wrapped around the body, without side seam, from the front to back and the back ties at the front with the pieces that have been removed from the neckline and wrist in order to be fitted (McQuillan & Rissanen, 2011).

Figure 13: Wrap dress ' Chinese Square' by Zandra Rhodes

Yoehlee Teng is another contemporary pioneer who emerged in 1980s. Fabric waste reduction is the key element in her aesthetic; as she states “Conservation of fabric, labor and time are part of my design decisions” (Major & Teng, 2003). Therefore, there is little or no fabric wastage in her designs. She minimizes waste by utilizing the full width of the fabric in her design layout. The width of the fabric and the design layout both help to minimize the waste. Most of her designs are loose fitting or made in one-size-fits-all, which can minimize fabric waste (Major & Teng, 2003). Her zero-waste one-piece coat from 1977 (Figure 14) is similar to the Japanese kimono design since the pattern is made from rectangles and the shoulder and side seams are substituted with folds. From her point of view “the seams that hold the clothes together are decorative elements” (Major & Teng, 2003).

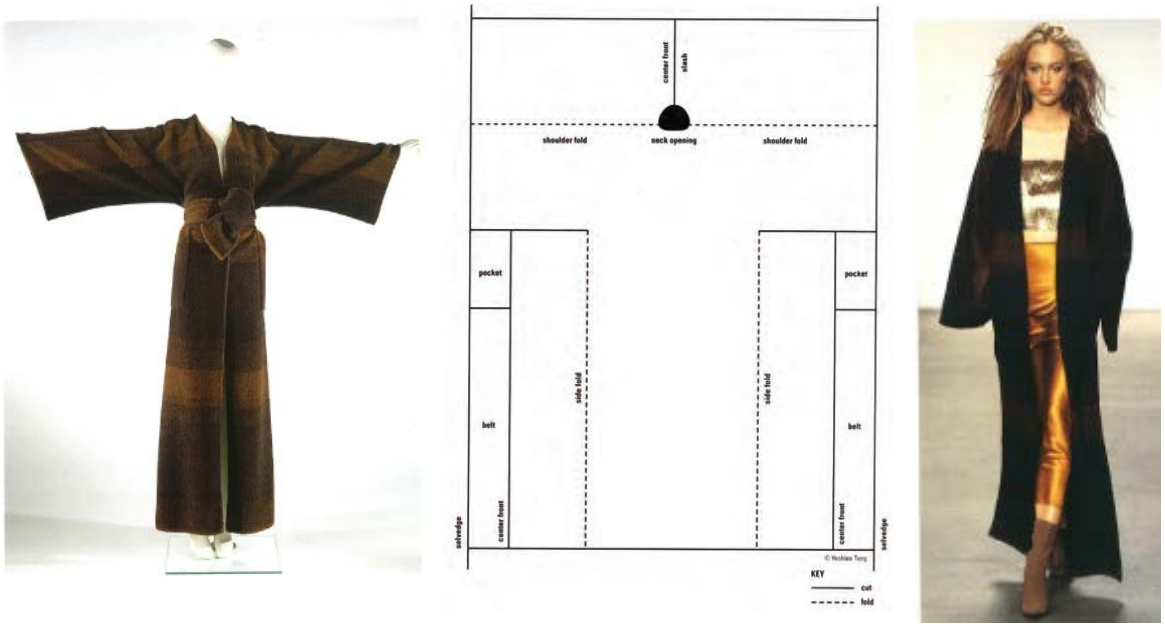

Figure 14: Urban nomad - one piece coat

The first decade of the twenty-first century has seen the emergence of more zero-waste fashion designers who have started eliminating or reducing waste in their designs in different ways. One way to approach zero-waste design is to reuse fabric scraps from the cutting process as an embellishment in the garment. Natalie Chanin, founder of the American company Alabama Chanin, has established her company based on the principle of sustainability. All the garments are made with either organic or recycled materials by the hand of local artisans (Figure 15). Any waste fabric is used as an embellishment, patchwork, or appliquè (Brown, 2010). Mark Liu is another designer who converts the negative space of the fabric to positive by cutting the edges with laser cutter and using them as decorative external seams. The print of the dress in Figure 16, designed by Liu, prevents the cut edge from raveling (Rissanen, 2008).

Figure 16: Alabama Chanin

Figure 15: Mark Liu's laser cut zero-waste design

Holly McQuillan is another sustainable designer who identified different ways of eliminating negative space by manipulating pattern pieces. She explains her process and approaches in the chapter titled ‘Zero-waste design practice: strategies and risk taking for garment design’ in *Shaping Sustainable Fashion* (McQuillan, 2011). McQuillan outlined four design practices in zero-waste apparel design, which will be explained briefly with examples. The first practice design is Tessellation, which consists of one shape or motif that repeats to fill the width and length of the fabric. Depending on the tessellated shape, there would be wasted areas that are not included in the design (Figure 17a), which is mostly along the selvedge of the fabric. Holly McQuillan has tried different ways to overcome this problem; one is using mathematical objects called fractals, which have random shapes to reduce or eliminate the waste at the edges. However, such a method would need considerable mathematical work and calculation. The other solution (Figure 17b) would be using smaller tessellated patterns as they get close to the edges of the fabric

(McQuillan, 2011).

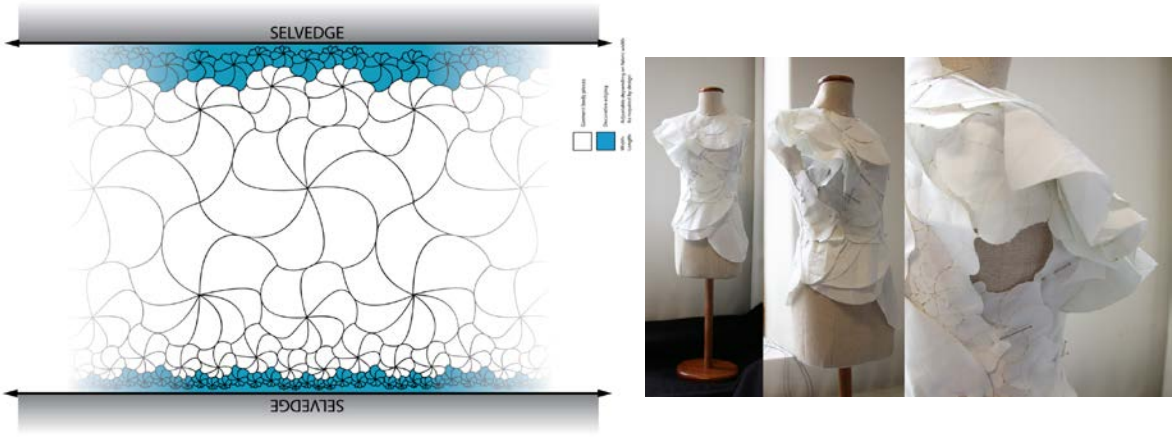

Figure 17: (a) Reducing tessellated design; (b) Garment design from tessellation

Carrico and Kim (2013) suggest using tessellated shapes with straight edges instead of curved ones to meet the fabric width. Carla Fernandez in her *Chamula outfit* (Figure 18) uses the tessellation method with triangle tessellated shapes for skirt and other shapes for the rest of the garment to use fabric efficiently (McQuillan & Rissanen, 2011; Carrico &Kim 2013).

Figure 18: Chamula outfit design by Carla Fernandez with tessellation pattern

The shortcomings of such an approach are that the final look is not predictable before the cutting process is finished. Second, this method cannot follow the curves of the human body; as McQuillan states, “the process of applying these shapes to a dress form leads to a garment design process more akin to sculpture than drape” (McQuillan, 2011). Finally, the whole process could consume a greater amount of fabric in comparison to a conservative, modern cutting method.

The second practice design is Jigsaw, which requires the designer to be proficient in pattern cutting techniques in order to manipulate the pattern pieces to interlock with each other without any fabric waste (McQuillan, 2011). In contrast to the tessellation method, a variety of different pattern shapes may be used and, like the tessellation method, the pattern is the generator of the garment design; therefore, the final look is unexpected. McQuillan (2011) uses two factors as guides to start her design process: first “the width of the fabric” and second “the fixed area.” The fixed area is the only area of the design that is predictable and will be the foundation of the design from which the rest of the design radiates outward; it might be the shape of the neckline or a decision on the fitting of a specific part of the garment. McQuillan’s goal is to eliminate waste rather than use less fabric; thus she does not restrict the design to a specific yardage (McQuillan, 2011). Thus, for designing zero-waste garments the designer needs to have a complete and clear plan, which involves not only the technical details but also considers the final appearance of the garment. Unlike the typical pattern making process, the placement of all the pattern pieces in zero-waste design must be planned simultaneously in order to interlock the pieces. While zero-waste design approaches require more time than conventional fashion design, the benefit is in the reduction of the ecological footprint by reducing waste of resources.

Timo Rissanen is one of the most prominent zero-waste designers. The men's denim jacket illustrated in Figure 19 is an example of one of his Jigsaw designs. Since the fixed area is the foundation of a garment resulting from Jigsaw design, it may lead to use of the remnants of fabric in the design inappropriately. McQuillan (2011) suggests Embedded Jigsaw to overcome this problem. This method enables the design of multiple garments simultaneously by utilizing the negative space for another garment to achieve zero-waste. Holly MacQuillan, in her design illustrated in Figure 20, treats the hooded jersey (embedded pattern) as the fixed area and uses the fabric wastage for the T-shirt.

Figure 19: Men's denim jacket by Timo Rissanen

Figure 20: Hoody & T-shirt designed by MacQuillan - embedded design

Menswear designer, David Telfer, investigates a variety of approaches toward utilizing fabric wisely and efficiently through pattern-making. In his approach, minimal seam construction system has been established to address embodied energy involved in the production process, in addition to the reduction in fabric waste. For example, this system can speed up garment production with reduction in energy consumption and labor. As reported in *YIELD Catalogue*, Telfer believes that in order to be successful "a balance between aesthetics, fabric consumption, complexity of construction, and fit constraints" is the goal of the Minimal Seam Construction (McQuillan & Rissanen, 2011). The minimal duffel coat (Figure 21) is an example of the Minimal Seam Construction method to produce a garment with zero-waste quickly (Telfer, n.d.). He was inspired by history and various cultures around the world, where zero-waste approaches have been used (McQuillan &

Rissanen, 2011). The zero-waste jacket illustrated in Figure 22 was a collaboration between North Face and TED (Textile Environment Design) with 23.2% fabric efficiency in comparison to their current pattern (Telfer,n.d.).

Figure 21: Minimal duffel Coat by David Telfer

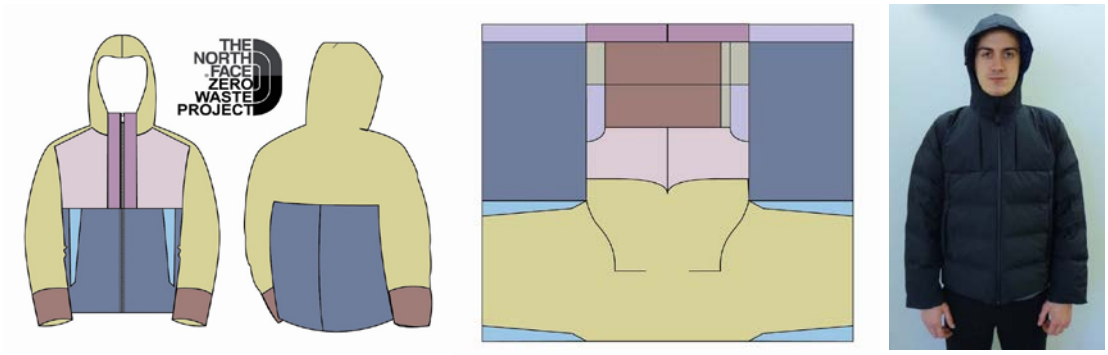

Figure 22: North Face zero-waste project designed by David Telfer, from Telfer website

In order to eliminate fabric waste, the designer needs to have a clear plan of a design since the technical and visual features of a garment need to be thought through simultaneously. The designer must also consider the shape of the pattern pieces and how they can be interlocked on the fabric. Bearing in mind all these elements in two-dimensional form is demanding. According to Rissanen (2008), difficulties of using two-dimensional flat pattern pieces may be solved by draping techniques, which involves the three dimensional form of patternmaking. Transformational Reconstruction is an

innovative patternmaking technique by a Japanese designer, Shingo Sato, where manipulation of pattern pieces is three-dimensional rather than two-dimensional. In this technique, the pattern is created by drawing desirable design lines on an already fitted control toile. Conventional fitting devices, such as darts and waistline seams, can be eliminated by converting to the seam control of the drawn design lines. In order to use pattern pieces in two-dimension, the toile is removed from the dressfrom , cut apart on the design lines, and then laid flat on the fabric as pattern piece. The garment illustrated in Figure 23 was designed and constructed by the researcher in 2014 using this technique of Transformational Reconstruction. In doing the pattern layout, I noticed that I could have more efficient utilization of fabric in constructing garment, which leads me to test the feasibility of this technique for zero-waste application.

Figure 23: Variation on a Rose with Transformational Reconstruction (TR) by Elahe Saeidi

Having presented these examples of the major approaches toward zero-waste apparel design throughout history, this select group of zero-waste designers provided the guidance for the experimental zero-waste designs of this study. A broader list of contemporary zero-waste designers may be found in Appendix A.

CHAPTER 3

METHOD AND PROCESS

Comprehensive research about the evolution of zero/low waste garments, both historical and contemporary, has revealed the constraints and successes of these approaches toward eliminating or reducing fabric waste.

In conventional fashion production, 15 percent of the initial fabric is wasted through the cutting process (Cooklin, 1977). Eliminating 15 percent of the fabric waste in the cutting process, it does not mean that one is using 15 percent less fabric. Designing garments without fabric waste is the primary criterion in this study. This restriction means that the garment uses all of the fabric, both lengthwise and across the full width without any leftover areas. The goal of the zero-waste designs in this study is to minimize or eliminate the fabric waste, not necessarily to use less total yardage of fabric.

This study involved six zero-waste garments. Eliminating fabric waste needs a thoughtful plan before cutting process, which may take longer than creating a garment in conventional fashion design. At the beginning it may seem to be a negative characteristic to spend longer time in designing zero-waste garments; however, by taking into consideration that interlocking pattern pieces have shared cutting lines, the cutting process becomes faster than conventional fashion design.

Rissanen (2013) classified the three primary criteria for conventional fashion design as appearance, fit, and cost. According to Rissanen (2013), appearance is the principle criterion of fashion design and as such “includes attributes such as garment shape, balance, and use of color, texture and line” (p.78). Fit, the second criterion, indicates how

the garment is sitting on the body and the amount of ease incorporated in pattern pieces. Ease is subject to variation by consumer preferences and contemporary specifications, with some companies allowing more ease in an attempt to fit a wider range of body types versus companies that have a narrower customer niche. In most cases appearance and fit have a direct relationship with each other. In other words, the fit of the garment on the body has influence on the appearance as well. Cost, the third criterion, refers to the total expenses, including fabric, notions, labor and company overhead, that are involved in sending the garment to the retail store. While cost is one of these criteria for evaluating designs, in this study the reduction of cost by limiting the amount of yardage used in a design is not a goal. This study focuses on achieving the best appearance and fit as fabric waste in the cutting process is eliminated.

Since most companies use size 10 as the base size before grading up and down for a full range of sizes, garments in this study were designed in size 10. The goal of the study was to cover most of the practices that were reviewed in chapter 2; therefore, six zero/ low waste women's wear designs were developed and tested. While the new design practice called TR (Transformational Reconstruction) was not developed to produce zero-waste designs, it was examined to determine whether it could be applied toward zero-waste design.

The Jigsaw method with fixed area to eliminate fabric waste was used for the Design 1, which was a denim jacket, employing flat patterning techniques. The Jigsaw method with the full width of the fabric created Design 2 the halter neck top and Design 3 the street length day dress.

Since the tessellation usually produces some waste, the goal of Design 4 was to employ tessellation in a zero-waste application. In this case, the circle was the tessellated shape. The resulting design was a two-piece ensemble of a sleeveless, cropped top with a pleated skirt.

The final two designs (Design 5 and 6) were developed with the TR (Transformational Reconstruction) technique. For Design 5 draping was used to create a muslin toile with the desired fit. Then, various design lines were drawn on the toile in such a way as to eliminate the traditional means of fit, in this case darts and waistline seam. Design 6, also using TR technique started from a one shouldered top toile as the fitted-control garment. The pattern pieces were modified again, before cutting the second toile, in order to eliminate fabric waste.

Limitations

Since some zero-waste techniques, such as Tessellation, are not applicable to every type of design, there was no attempt made to force every zero-waste technique to produce the same style garment. Similarly, since some of the zero-waste techniques require specific characteristics of fabric performance, such as a non-raveling fabric edge for Tessellation designs, there was no attempt to make the same fabric perform in every technique or garment type.

Process

The general process of these experiments was making patterns by either draping or flat pattern techniques. After the desired pattern was made, the pattern pieces were laid on the width of fabric, as closely as possible, to determine whether fabric waste would result

before cutting. This step could be done manually on the fabric, using a paper marker layout or a computer screen image sized to the width of the fabric. In this study the manual layout of pattern pieces on fabric was utilized. In order to gain zero-waste, in some cases the pattern pieces were modified in order to interlock with each other, causing some minor changes from the initial design of the garment. As McQuillan (2011) states "… the pattern is the originator of the garment design" (p. 92); therefore, the final look of the garment is not fully predictable. Photography was used in each stage in order to document pattern development and toile fitting.

Evaluation

While it was easy to evaluate the six designs for achievement of zero/low waste designs goal, the question arises as how to determine whether these designs are appealing to the contemporary consumers. Therefore, in thinking about what makes a design basically appealing without being wearable art or extremely avant-garde, fit and appearance seem to be major factors as classified by Timo Rissanan (2013). To judge these criteria, the design-criteria form was developed to be utilized by a panel of the University of Alabama Clothing & Textiles faculty members. Each of the committee members evaluated each of the designs using the form and simple statistical analysis was done to determine if the zero-waste designs in this study were successful for the criteria of appearance and fit.

Appearance is the most challenging attribute to define, because different companies and designers may have various concepts/attributes about appearance of the garment. Therefore, I have defined this criterion and categorized its elements that will be part of my consideration in producing zero/low waste garments:

Element of Appearance:

1. *Zero/low waste look:* whether it is noticeable that the garment is made using a zero-waste method or conventional (because there is a conception that zero-waste garments look crafty, loose and bulky)
2. *Visual aesthetic:* the overall appearance of the garment.
3. "*Unity of design*: which exists when all elements in a composition work together for one purpose" (Brockman, 1995, p. 82). In other words, if all the parts look cohesive, belong to each other and nothing is out of scale or proportion.
4. *"A single strong focal point/ center of interest:* means that there is a specific element, which is the dominant contribution. All other elements should be in a supportive relation with the dominant element or the focal point (Brockman, 1995, p. 82).
5. "*A means of transfer of interest":* this holds when the observer's eye can move smoothly from the focal point to the wearer's face rather than staying on the focal point (Brockman, 1995, p.82).
6. *Elements of a design:* if the embellishment and details of the design are relevant to the design and not just used to minimize the waste.

Elements of fit:

Since design can vary between a very loosely fitted design to a close fitted design

1. *Set*: garment sits on body without undo wrinkle caused by improper grain position or improper size of the panel to fit the body part.

2. *Proper ease:* The amount of ease is appropriate to a design and purpose of the garment. For example, an outerwear coat would have more ease than a daywear suit.
3. *Hang of garment:* projects outward from the body equal distanced all around the figure.

Glossary of Terms

Fitted-control garment: in this study a muslin toile that is draped with the desired amount of fit using control darts and a waistline seam if it is full length dress rather than the top.

Flat Pattern: is a technique of patternmaking that creates design pattern with a master basic pattern (sloper) by using the pivot or slash method (Joseph-Armstrong, 2006).

Draping: refers to a technique that generates a design directly on the dress-form with fabric (Kiisel, 2013).

Grading: refers to "the process of systematically increasing and decreasing the size of the master pattern to create range of sizes" (Moore, Mullet et al,2001)

Toile: a French word meaning cloth; refers to the muslin trial or test garment (Burns & Bryant, 2007) to test the pattern and fitting of the garment before cutting the fashion fabric.

Zero-waste garment: Zero-waste garment in this thesis refers to garments that have been designed in such a way that all of the fabric is in the garment after cutting process, without any leftovers.

TR (Transformational Reconstruction): is a pattern technique developed by Japanese designer Shingo Sato, which provide the designer to create new style lines in 3-Dimentional toile (muslin) to deconstruct them into new pattern pieces.

Pattern layout: in this thesis refers to the layout of the pattern pieces on the fabric, which will be developed with Adobe Illustrator.

Low-waste garment: low-waste garment in this study refers to any garment that is produced with less than 10 percent waste; because the average waste is between 15 to 20 percent (Cooklin, 1977).

Jigsaw: refers to a pattern cutting techniques that interlock all the pattern pieces with each other without leaving any negative space (McQuillan, 2011).

Embedded jigsaw: this is another version of jigsaw that enables the designer to design multiple garments simultaneously by utilizing the negative space for another garment to achieve zero-waste (McQuillan, 2011).

The Design Criteria Evaluation Form can be found in Appendix B. while a broader test of design criteria would be desirable the submission of the design to a wider consumer base will be performed in a follow up study.

CHAPTER 4

RESULTS

Experiment 1: Jigsaw with Fix Area

In this experiment, the flat pattern technique was used to create the initial pattern. The Jigsaw Puzzle method with the fixed area was used to eliminate fabric waste. The fixed area is the foundation of the design, which cannot be modified to interlock the pattern pieces. In this practice the designer needs to be proficient in pattern cutting techniques for manipulating the pattern pieces to interlock with each other (Figure 24).

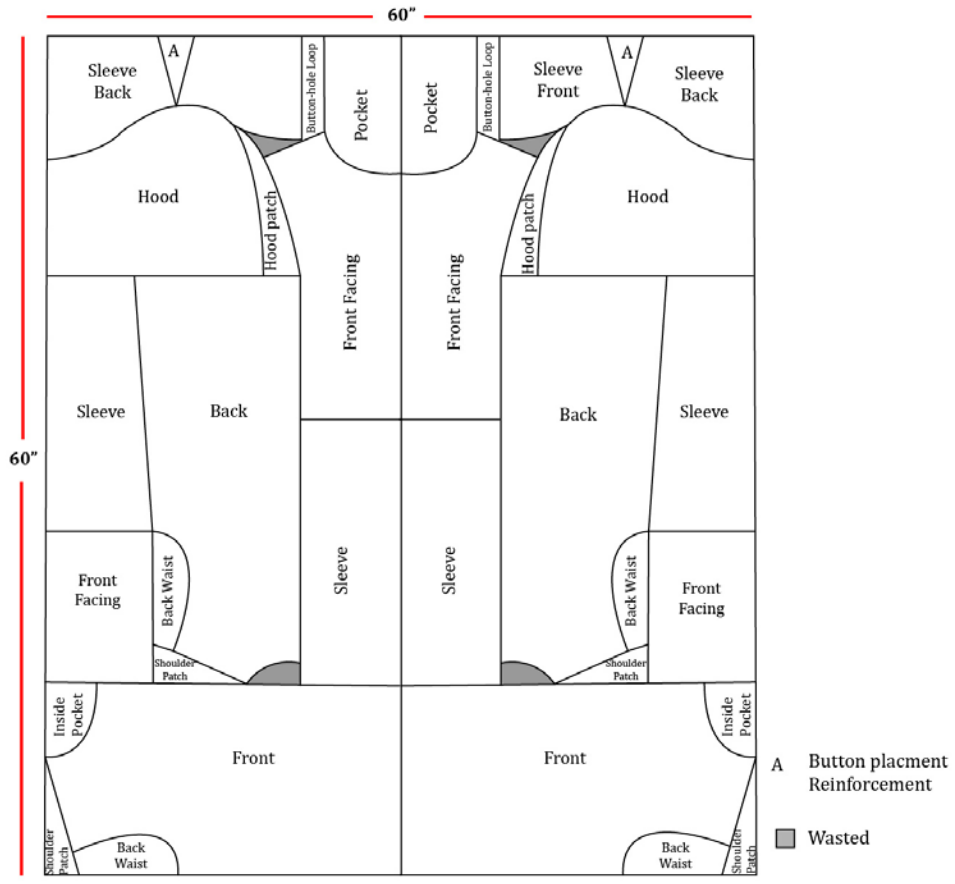

Figure 24 : Pattern layout of denim coat

The hood of the jacket was considered as the fixed area in this practice; therefore, I was able to make changes to any other piece than the hood. The front and back views of the jacket can be seen in Figure 25. For instance, the sleeve was one of the modified pieces that was constructed with 4-pieces instead of the usual one piece (Figure 26). These changes did not alter the overall design and silhouette of the garment. The negative areas were purposefully incorporated into the design without awkward attachment. An alternative look of the garment with the neckline unfastened is illustrated in Figure 27. My purpose was to integrate the negative space into the design either functionally or aesthetically (as self-fabric embellishment).

Figure 25: Front and back look of denim coat

Figure 26: 4-pieces sleeve

Figure 27: Unbuttoned look of the jacket

For instance, patches on shoulders, which resulted from the front and back shoulder seam slopes were reversed (Figure 28) and patches that were applied to the hood, which were negative space around the top of the hood (Figure 29) were included to the design as embellishment.

Figure 28: shoulder detail

Figure 29: Hood detail

Waste areas of front neckline were used functionally as an inside pocket with four stitched segmented chambers to hold pens (Figure 30). Small triangles resulting from cutting between sleeves pieces were functionally used as button placement reinforcement, since the buttons were heavier in comparison to the weight of the fabric, instead of using fusible interlining (Figure 31). Irregular negative space shapes resulting from creating the curvature of the armscyes were utilized functionally and aesthetically as an adjustable back waistband, which helped the fitting of the coat and gave it more feminine look (Figure 32).

Although I was not able to use 100 percent of the fabric, I was able to use fabric very efficiently. Only four very small wasted pieces with awkward shapes were not possible to be used either functionally or aesthetically, as can be seen in Figure 24 as the grayed areas. Therefore, I decided to leave them as waste instead of using them unskillfully.

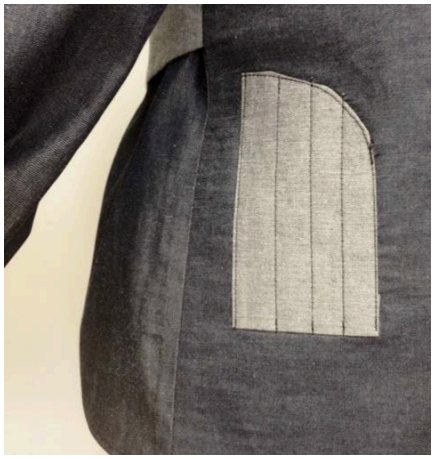

Figure 30: Inside pocket

Figure 31: Buttonhole placement reinforcement

Figure 32: Adjustable back waist

Experiment 2: Jigsaw with the full Width of Fabric

In this experimental garment, the draping technique was used to develop the zero-waste design. Rectangular pieces were used to create pattern; however, the silhouette of the final look was determined before draping; then details of the design and fitting were discovered after the draping process. Depending upon the width of the fabric and the size of the dress-form, the look of the garment is different. For instance, the fullness and gathering of the top for a 60” wide fabric is different from the 45” wide fabric on the same size dressform. As can be seen from the pattern below, the entire width and length of the initial fabric is used to make this top (Figure 33). To shape the back for close fit on the body, single-fold-bias tape was used to form the casing, for inserting the elastic (Figure 34). Twill tape was used to prevent stretching along from the front bias edges from underarm to neckline. The final front and back looks can be seen in Figure 35.

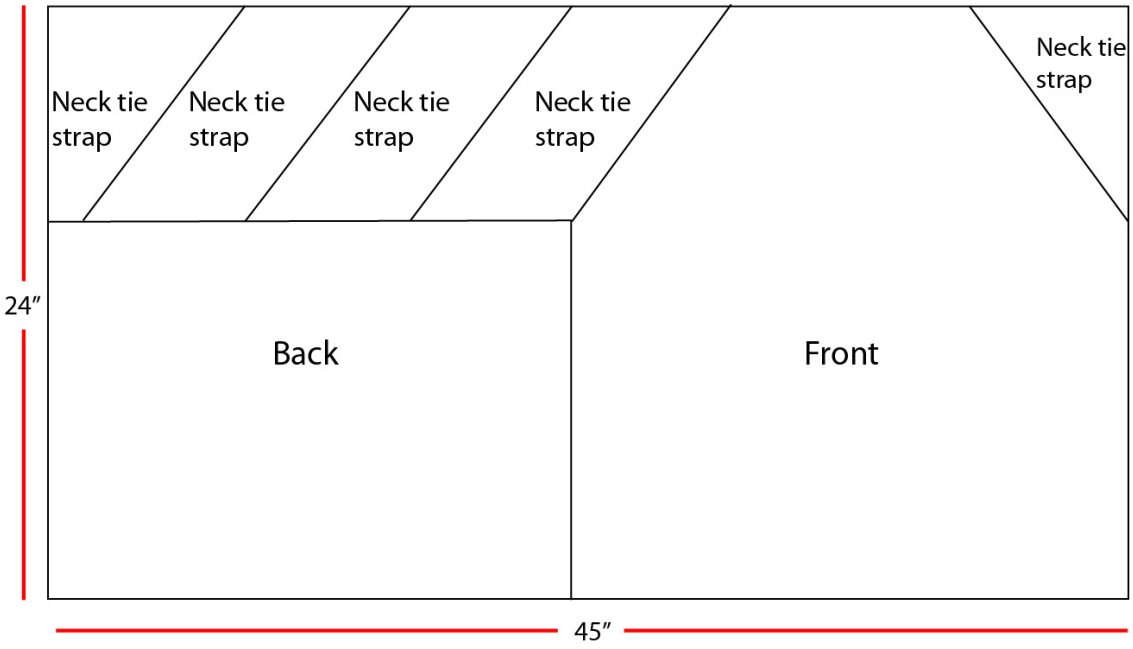

Figure 33: Pattern layout of halter top

Figure 34: Back casing

Figure 35: Front and back look of halter top in fashion fabric

Experiment 3: Jigsaw with the full Width of Fabric

Using geometric shapes with straight edges, such as rectangles, squares, triangles, pose a different way to utilize fabric more efficiently and eliminating fabric waste. The first idea that I had about the zero-waste garments was the Japanese kimono, which is made entirely of rectangular pieces of fabric cut from the cloth from selvedge to selvedge. I came up with design 3, while I was reviewing the historical fabric-efficient garments and learned about Yoeohlee Teng, who minimizes waste by utilizing the full width of the fabric in her designs. Most of her designs, such as urban nomad one-piece coat (Figure 14), is loose fitting or made in one-size-fit-all.

In this experiment, I worked on a dressform and draped a garment with two rectangular pieces of fabric. Shoulder seams were integrated into design. Since the design had a center front seam, horizontally patterned fabric was selected to help line up the pattern pieces across the center front and center back seam lines (Figure 36). Since contemporary women's wear is showing garments with loose back and a front fitted through the use of a waist cincture coming from the side seams across the front of the garment, this design explored the use of a waistband just across the front to make the garment fitted at the front and loose at back. Since the choice of color and pattern have profound effects upon the acceptance of garment, the design were fabricated twice once in patterned fabric and secondly in solid color fabric. As can be seen in Appendix C evolution of the garments, the acceptance of the pattern fabrication was the least acceptable of all the zero-waste garments. During the oral presentation the teal fabrication was very favorably received.

Figure 36: Front and back look of Jigsaw with the full width of fabric in first and second fabrications

Experiment 4: Tessellation

In this design experiment, I investigated a possible solution for eliminating negative space in the Tessellation practice. As explained before, one shape or motif repeats to fill the width and length of the fabric; and dependent upon the tessellated shape, there would be a negative space along the selvedge. One solution to eliminate these negative spaces and use 100% of the fabric is using a smaller scale version of that tessellated motif as they get close to the selvedge, which still leaves negative space along the edges (McQuillan, 2011). Another way to overcome this problem is using a tessellated shape with straight edge instead of curved one to use the entire width, including the selvedge area (Carrico & Kim, 2013). As discussed above by McQuillan (2013), layering tessellated shapes on a dressform to create a garment out of tessellated shapes would result in having a sculptured garment rather than a draped one.

In this experiment, I tried to eliminate fabric waste by using curved motif while keeping the more traditional appearance and flattering the curvy, feminine silhouette. I was inspired by a fragment of silk fabric with several cut out circles, which I saw when I was an intern at Heidi Elnora, a contemporary bridal designer. Circles were cut out from the fabric erratically for making cloth-covered buttons, which at first glance appeared to me as a lace or eyelet fabric (Figure 37). The equipment of circle dyes and cutter shown in Figure 38 is typically used for cutting out circles. Then I thought about making a textured fabric by cutting out circles in an organized manner and using these circles as self-fabric embroidery or at least another piece, since I did not want to waste any fabric.

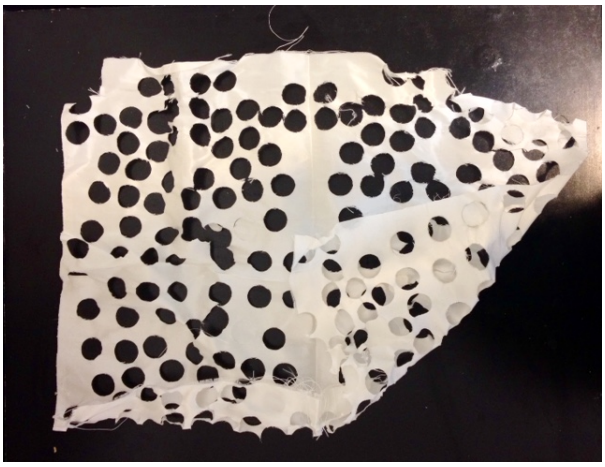

Figure 37: Silk fabric with cut out circles for cloth-covered button

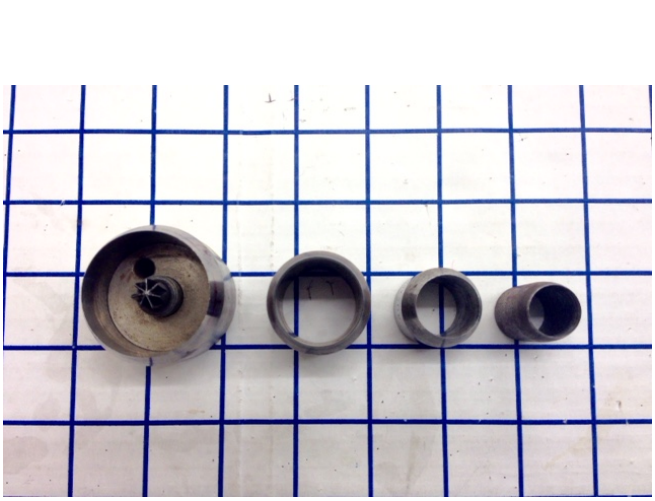

Figure 38: Circle blades and cutter

To start my Tessellation design journey, a two-piece garment was designed. A crop top was made with tessellated pieces only and a pleated skirt with the fabric resulting from the cutting out of circles of different diameters from around the bottom of the skirt yardage. To test the idea and figure out about the desirable fit and length of the skirt, a toile skirt was created with 24 inch wide gingham (Figure 39).

Figure 39: Toile of tessellation design

After constructing the skirt and cutting out circles, a several changes were made to the initial design. One of them was shortening the length of the skirt and the other one was using the entire width of the fabric in order to have sufficient circles to make the top and have a flare-look skirt rather than straight.

My first concern for generating a garment using tessellation was choosing drapable fabric that does not ravel easily, since finishing the edge of the tessellated pieces and the cut work areas would be time consuming. If not done perfectly, it would have a negative influence on the final appearance of the garment. Therefore, I chose matte, resin-treated knit that looked like leather. The fabric was folded crosswise and divided into two pieces by cutting along the fold. One whole width piece was used for the front and the other for

the back. In order to create a more aesthetic cutwork fabric, it was determined that different sized circles would offer an interesting rhythm and provide material for making the top. I preferred to work with folded width of the fabric in order to save time and have a symmetrical look. After the formation of the circles around the hem was adjusted and confirmed, two layers of the fabric were basted to avoid slipping while punching the circles. Since a needle would make holes in this type of fabric, basting stitches were done along the cutting edge of the circles (Figure 40).

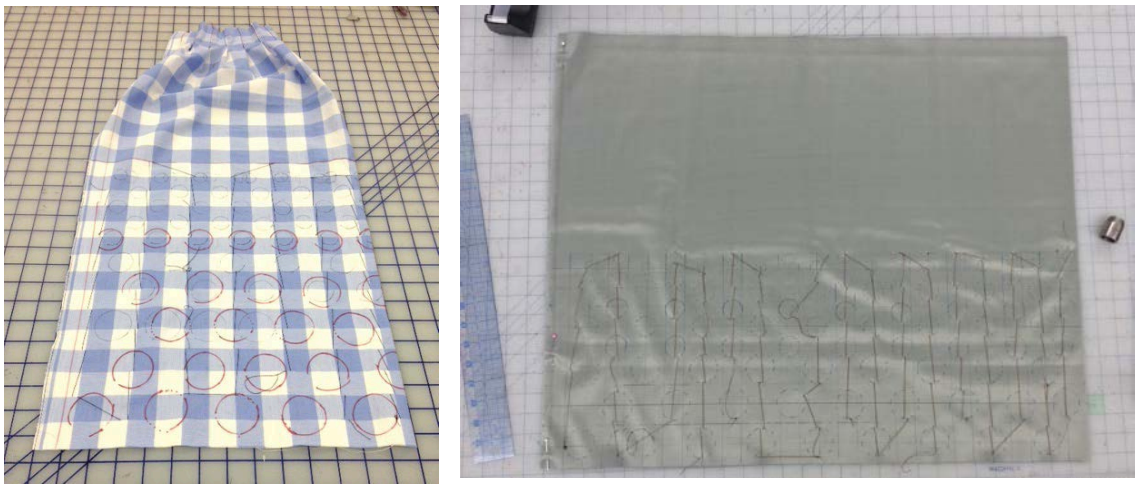

Figure 40: Toile (left) and fashion fabric (right) with scaled tessellated motif

The waist was fitted with topstitched knife pleats and closed with an exposed zipper at the center back. Sine this zipper had a gold metal teeth embedded in a black tape pleats were topstitched in black to keep the cohesiveness of the design as well as using black joining stitches for the top. To prevent the waist from stretching, a ⅝ of an inch wide, grosgrain waist stay was applied to the waist of the skirt with black topstitching to keep the skirt on the body (Figure 41).

Figure 41: Tessellation design

Experiment 5: TR-1 (Transformational Reconstruction-1)

In conventional fashion design, the final look of the garment is planned in a two-dimensional sketch and confirmed by making and cutting the pattern of the three-dimensional garment. Transformational Reconstruction is a new draping and pattern-making technique that manipulates a garment in 3D, not in 2D. Utilizing this technique toward zero-waste involves a very different design process. Unlike the traditional design process where a designer creates the pattern pieces for the design and then tests the pattern by making a muslin toile, this technique started with a control fitted garment. The designer then drew the desired design lines, using expertise in patternmaking and design in order to place the design lines in an appropriate place to keep the shape and fitting of this controlled fitted garment.

In this experiment, my process began by draping a basic bodice and skirt with waist dart control. In order to interlock pattern pieces, straight lines were used. For ease of interlocking and cohesive appearance, I drew the design lines in such a way that all pattern pieces would have the same width at opposing edges (Figure 42). In developing the cutting lines, the muslin was removed from the dress form and cut open on the design lines. Then the pattern pieces were placed on the fabric until the most efficient use of fabric was achieved (Figure 43). Some corrections were applied to the pattern pieces for a zero-waste design. Fabric choice is also critical to the appearance because all the pattern pieces needed to be cut from one fabric. In this test, a double-sided fabric was used, which allowed for the pieces to use the reverse side for a two-color pattern effect overall (Figure 44). Smaller triangular pieces were used to get a better armscye shape at the intersection with the side seam (Figure 45). The negative spaces were converted to bias pieces for finishing the armscyes and bottom hem line.

The common belief about zero-waste garments is that bulky and loose silhouette with unusual appearances. In this practice, I realized that applying TR toward zero-waste design could lead the designer to design fitted garment and still use fabric efficiently. A second zero-waste garment was created with TR technique to show that with this method making fitted zero-waste garments are possible.

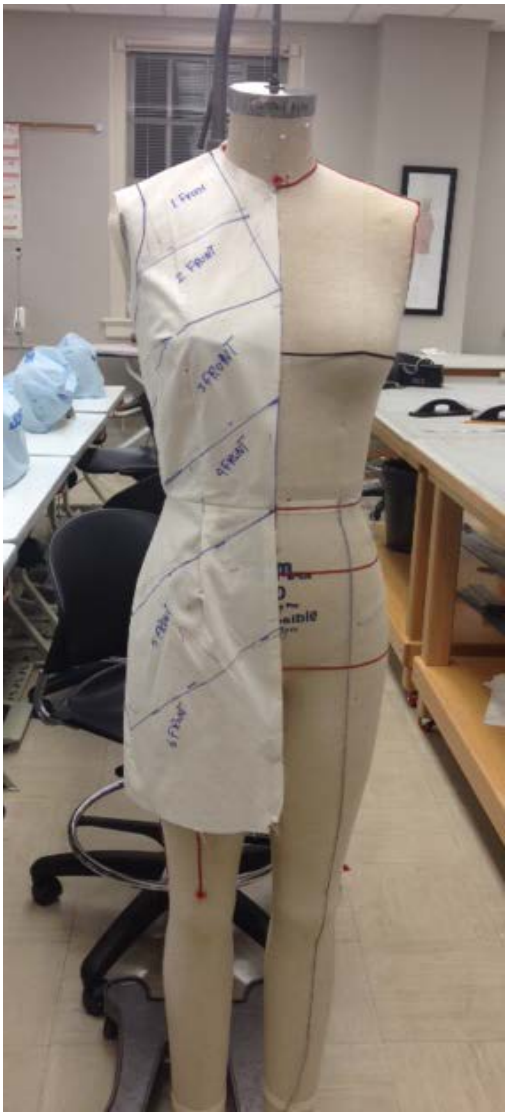

Figure 42: Front of the second toile

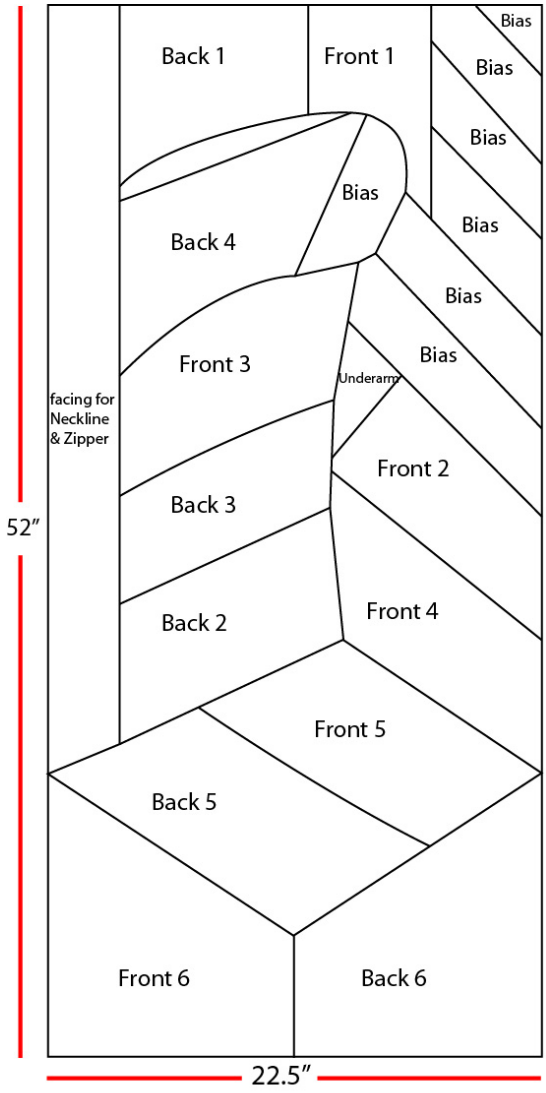

Figure 43: Pattern layout of Transformational Reconstruction 1

Figure 44: Front and back look of TR-1 design

Figure 45: Underarm detail

Experiment 6: TR-2 (Transformational Reconstruction-2)

Experiment 5, was successful in designing a fitted zero-waste garment with Transformational Reconstruction. Even though the silhouette of the control fitted garment was very curvy and close fitting, utilizing straight lines helped to interlock pattern pieces and create fitted zero-waste design. Therefore, in this Experiment 6, I examined if TR would be applicable with curved and non-straight lines as well.

Different designs with curved lines were explored to use fabric efficiently, all of which did not quite succeed in achieving zero-waste. The use of curved design lines required a greater amount of mathematical calculation in order to fit one curve into another. Considering the fact that all the processes from patternmaking to altering the pattern pieces to making the garment were done manually in this project, having curved lines in a symmetrical design was very demanding and time consuming. Therefore, I decided to design an asymmetrical look, which required working full width instead of half. Using an asymmetrically fitted-control garment, in this exercise, was the designer's choice. After constructing the asymmetrically fitted control toile, various design lines, each using a different color, were drawn until the most desirable design lines were established (Figure 47). Then the toile was removed from the dressform and cut open. I tried to draw the lines along the waist-fitting darts in order to be able to lay the pattern pieces flat on the fabric. Since the bust darts were not integrated into design lines, they were unstitched and placed on the fabric to lie smoothly. One of the back-fitting darts was incorporated into design lines and the other back dart was opened to lay flat for cutting; but was made in the final garment. After all the pieces were placed on the fashion fabric in the least wasteful formation, there were still some negative spaces around the pattern pieces. Unused piece were colored on the pattern lay out (Figure 47).

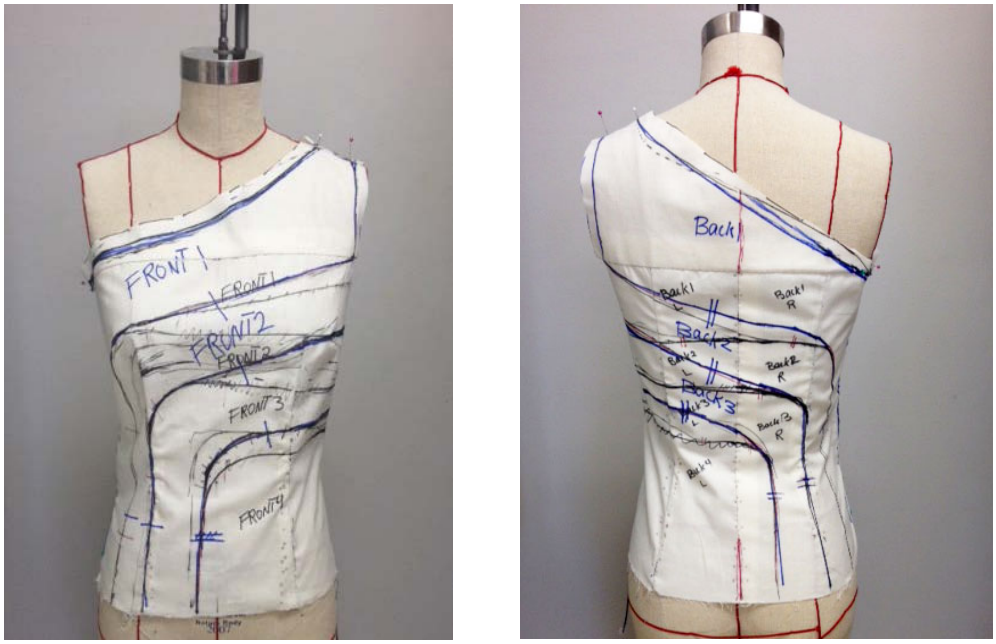

Figure 46: Front and back look of fitted control top with design lines

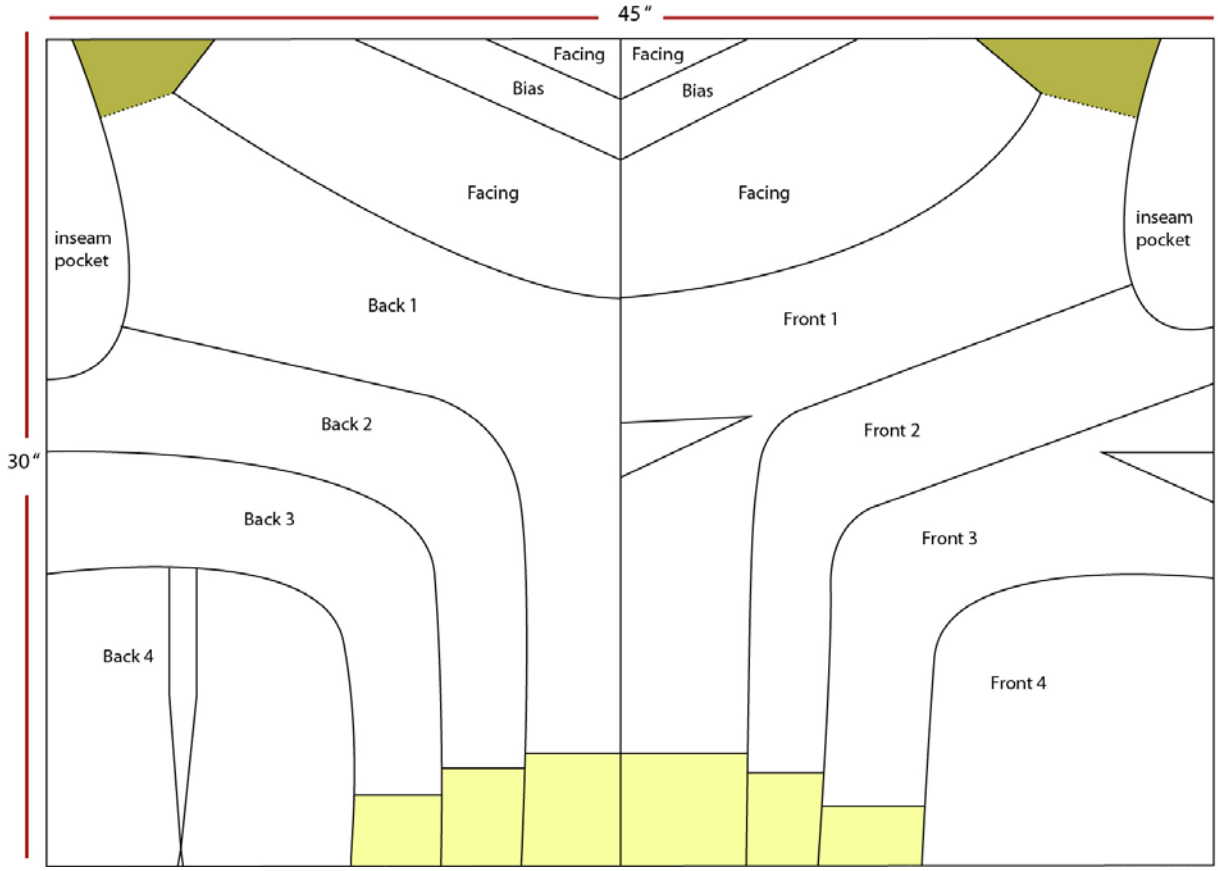

Figure 47: Pattern layout of Transformational Reconstruction 2

Since my role in this project was as both fashion designer and pattern maker, I decided to make some changes in the design to use fabric more efficiently as shown in the final look of the garment in Figure 48. The yellow areas were incorporated to the length of the longer vertical pieces, which resulted in having a graduated hemline and were coherent with the initial design (Figure 49). Green areas above the shoulder were also integrated into design and used as a self-fabric bow (Figure 50). The armhole was finished with the semi-bias strips from above the facing pieces. Waste areas at the front and back armscyes were also used functionally as an inseam pocket.

Figure 48: Front and back look of final garment with TR technique

Figure 49: Graduated hem

Figure 50: Bow

To judge the consumer acceptance of these designs is beyond the scope of this paper; but to prepare for a larger sampling of reactions, a pilot study instrument was designed and tested by departmental graduate faculty. It is clear that the first question is apt to cause bias in the viewing of the designs and should be changed in such a way as to survey whether the design looks unnaturally contrived to get zero-waste versus standard design and construction. The ideal would be to have the garment be a zero-waste garment without looking deviant from contemporary fashion.

The questionnaires were completed by four University of Alabama departmental graduate faculty members. As stated above, the common belief about zero-waste garments is that they have an unusual appearance. My aim in this study was to create zero-waste garments with typical appearance and the standard silhouette of contemporary women's wear. Therefore, the questions were categorized in two sets: appearance and fit. It should be noted that the responses to the questions of this survey may have been highly affected by personal tastes and should not be generalized. However, the fact that all of the participants provided positive feedback for nearly all the garments demonstrates that zero waste approach can result in creating fashionable

garments with creative designs and innovative pattern making techniques. Since one of the questions asked by the study was whether Transformational Reconstruction (TR) could be applied toward zero-waste, the outcome of the survey for Designs 5 and 6 are discussed in more detail here.

By assessing the responses of TR-2 (Design 5), which was designed and constructed with TR technique, I found out this method enables the designer to create a fitted zero-waste garment. Responses for the TR-1 indicated that the appearance of the garment was appealing and rated as "excellent" in all questions related to appearance. Regarding the appearance of TR-2 (Design 6) that was also created with the TR technique, all the participants rated the appearance of the garment as "excellent" except the last participant, who rated the garment as "good". Similar evaluations were given by the same participants regarding the fit of the garment.

Additionally, the garment that was created with the *Tessellation* method (Design 4) was ranked as "excellent" in both appearance and fit by all panel members, which indicated that the experiment was successful to overcome all the aforementioned problems of this method. According to McQuillan (2011) the process of applying tessellated shapes "lead the garment design process more akin to sculpture than drape" (p.89) and therefore possibly looking contrived, evaluations of the panel responses indicated that the appearance and fit of the *Tessellation* (Design 4) was pleasing to all of the participants of this study.

The detailed responses of all of the participants to the survey for all six garments are provided in Appendix C.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

In this practice-based research, different methods were explored to reduce or eliminate fabric waste from the cutting process of creating garments. With the increasing number of fashion designers working for store brands or starting their own lines, we have the potential for creating rapid increase of fabric waste in the cutting process. In order to prevent this from happening, designers need to be encouraged to think about changing their design process one that focuses upon reducing and eliminating fabric waste before the garment reaches the consumer. While sketching has been the initial step in design process, in order to eliminate fabric waste the designer and pattern-maker need to work as a team and collaborate with each other as the design moves from the initial sketch through pattern-making and the cutting processes.

Without changing the basic silhouette of contemporary women's wear, six garments were designed and constructed with different zero-waste methods. A new approach, Transformational Reconstruction, was introduced and tested for eliminating of fabric waste to demonstrate its feasibility in designing zero-waste garments. Since the output of the zero-waste design is often unpredictable, McQuillan (2011) states that zero-waste design practice is one of the "embracing unpredictable design process as a creative advantage" (p. 96). Utilizing Transformational Reconstruction (TR) enabled the designer to think and design three-dimensionally rather than two-dimensionally and gave the designer more control over the final look of the garment.

Since the silhouette of the contemporary women's wear is fitted or semi-fitted, my aim for this project was to design aesthetically pleasing garments with the same contemporary desired fit and appearance, using the zero-waste approach.

In terms of continuing this research, a larger sample of randomly selected individuals will be surveyed to assess the potential for acceptance by consumers for these zero-waste designs. Interlocking pattern pieces leaves no room to reduce or increase pattern pieces, because changing one piece impacts another, which is a limiting factor for changing each design for a whole size range. To apply zero-waste in mass-production, more research is required for grading patterns to produce the usual size range of several sizes. While none of the designs created for this study had linings and many contemporary women’s wear garments do contain linings for covering inside construction, building body into the garment and providing long-term stability and shape retention, further testing with linings as part of the design would need to be explored.

With contemporary design and construction methods effectively using 85% of the fabric expended in a garment, the application of zero-waste design techniques would improve fabric utilization to reduce this waste. While taking more time at the beginning of the design process, the designer and pattern maker essentially solve the problem of what to do with fabric scrap before they become a real problem. This efficiency of cloth use reduces the environmental impact of the loss of energy and material inputs for the textile formation as well as increased cost of transportation and disposal fabric waste. The end result would be a more profitable apparel production enterprise.

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APPENDIX A

List of Zero-Waste or Low-Waste Designers:

This list is collected during working on the review of literature of this project. Part of it is collected from Timo Rissanen's webpage (Rissanen, 2010), which was my initial spot to start my research about contemporary zero/low waste designers and some of them found me through my Facebook fan page when I posted some pictures regarding my research in this field. This list covers all the designers of whom I am aware and those who inspired me during my design journey to complete this study.

The pioneers:

Dorothy Burnham

Madeleine Vionnet

Claire McCardell

Bernard Rudofsky

Zandra Rhodes

Yeohlee Teng

Julian Roberts

Material by product

Alabama Chanin (Natalie Chanin)

Ernesto Thayaht

More recent, in no particular order:

Timo Risannen

Mark Liu

Holly McQuillan

Carla Fernandez

Tara St James/ Study NY

Jennifer Whitty

David Telfer

Andrew Hague

Caroline Priebe

Samuel Formo

August

Tiffany Ouyang

Yingxian Xiao

Julian Lumsden

Carlos Villamil

Shreya Upadhyaya

Siddhartha Upadhyaya

Dusanka Duric

Daniel Silverstein

APPENDIX B

Design Criteria Form

Name/number of the design:		
Appearance	1. Zero/low waste look	Yes No
	2. Visual aesthetic	Weak Good Excellent
	3. Unity of design / Cohesive	Weak Good Excellent
	4. A single strong focal point	Weak Good Excellent
	5. A means of transfer of interest	Weak Good Excellent
	6.Elements of a design	Weak Good Excellent
Fit	1. Set	Weak Good Excellent
	2. Proper ease	Weak Good Excellent
	3. Hang of the garment	Weak Good Excellent
Comment		

APPENDIX C

Result of the Questionnaire

<table>
<tr>
<td>DESIGN 1

Method: Jigsaw with fix area

 
</td>
<td>Appearance</td>
</tr>
<tr>
<td></td>
<td>1. Zero-waste look or not? 3 out of 4 respondents believed that the design does not look zero-waste.</td>
</tr>
<tr>
<td></td>
<td>2. Visual aesthetic: 3 out of 4 rated the visual aesthetic of the design “Excellent” and 1 rated as “Good”</td>
</tr>
<tr>
<td></td>
<td>3. Unity of design: 4 out of 4 rated the design “Excellent” in cohesiveness</td>
</tr>
<tr>
<td></td>
<td>4. A single strong focal point: 4 out of 4 rated this feature “Excellent”</td>
</tr>
<tr>
<td></td>
<td>5. A means of transfer of interest: 3 out 4 rated as “Excellent” and one as “Good”</td>
</tr>
<tr>
<td></td>
<td>6. Elements of design: 4 out of 4 rated the design “Excellent” as the details and embellishments are relevant to design</td>
</tr>
<tr>
<td></td>
<td>Fit</td>
</tr>
<tr>
<td></td>
<td>1. Set: 2 out of 4 rated “Excellent” and 2 rated as “Good”</td>
</tr>
<tr>
<td></td>
<td>2. Proper ease: 3 out of 4 rated the ease of the design “Excellent” and 1 rated as “Good”</td>
</tr>
<tr>
<td></td>
<td>3. Hang of garment: 3 out of 4 believed the hang of the garment was “Excellent” and one ranked as “Good”</td>
</tr>
</table>

DESIGN 2 Method: Jigsaw with full width of fabric 	**Appearance**
	1. *Zero-waste look or not?* 3 out of 4 respondents believed that the design does not look zero-waste.
	2. *Visual aesthetic:* 3 out of 4 rated the visual aesthetic of the design "Excellent" and 1 rated as "Good"
	3. *Unity of design:* 2 out of 4 rated the design "Excellent" in cohesiveness; 2 rated as "Good"
	4. *A single strong focal point:* 2 out of 4 rated this feature "Excellent"; 1 rated as "Good" and 1 as "Weak"
	5. *A means of transfer of interest:* 2 out 4 rated as "Excellent" and 2 as "Good"
	6. *Elements of design:* 3 out of 4 rated the design "Excellent" as the details and embellishments are relevant to design and one as "Good"
	Fit
	1. *Set:* 2 out of 4 rated "Excellent" and 2 rated as "Good"
	2. *Proper ease:* 3 out of 4 rated the ease of the design "Excellent" and 1 rated as "Good"
	3. *Hang of garment:* 3 out of 4 believed the hang of the garment was "Excellent" and one ranked as "Good"

DESIGN 3 Method: Jigsaw with the width of fabric 	**Appearance** 1. *Zero-waste look or not?* 3 out of 4 respondents believed that the design looks zero-waste. 2. *Visual aesthetic:* 1 out of 4 rated the visual aesthetic of the design "Excellent" and 1 rated as "Good" and 2 as "Weak" 3. *Unity of design:* 1 out of 4 rated the design "Excellent" in cohesiveness; 2 rated as "Good" and 1 as "Weak" 4. *A single strong focal point:* 2 out of 4 rated this feature "Good"; 2 rated as "Weak" 5. *A means of transfer of interest:* 1 out 4 rated as "Excellent" and 2 as "Good" and 1 as "Weak" 6. *Elements of design:* 1 out of 4 :"Excellent" and 2 as "Good" and 1 as "Weak" **Fit** 1. *Set:* 2 out of 4 rated "Good" and 2 rated as "Weak" 2. *Proper ease:* 2 out of 4 rated the ease of the design "Excellent" and 2 rated as "Good" 3. *Hang of garment:* 1 out of 4 believed the hang of the garment was "Excellent" and 2 ranked as "Good" and 1 as "Weak"

DESIGN 4 Method: Tessellation 	**Appearance**
	1. *Zero-waste look or not?* 3 out of 4 respondents believed that the design does not look zero-waste.
	2. *Visual aesthetic:* 4 out of 4 rated the visual aesthetic of the design "Excellent"
	3. *Unity of design:* 4 out of 4 rated the design "Excellent" in cohesiveness
	4. *A single strong focal point:* 4 out of 4 rated this feature "Excellent"
	5. *A means of transfer of interest:* 3 out 4 rated as "Excellent "and 1 as "Good"
	6. *Elements of design:* 4 out of 4 rated the design "Excellent" as the details and embellishments are relevant to design
	Fit
	1. *Set:* 4 out of 4 rated "Excellent"
	2. *Proper ease:* 4 out of 4 rated the ease of the design "Excellent"
	3. *Hang of garment:* 4 out of 4 believed the hang of the garment was "Excellent"

DESIGN 5 Method: Transformational Reconstruction 	**Appearance**
	1. *Zero-waste look or not?* 4 out of 4 respondents believed that the design does not look zero-waste.
	2. *Visual aesthetic:* 4 out of 4 rated the visual aesthetic of the design "Excellent"
	3. *Unity of design:* 4 out of 4 rated the design "Excellent" in cohesiveness
	4. *A single strong focal point:* 4 out of 4 rated this feature "Excellent"
	5. *A means of transfer of interest:* 4 out 4 rated as "Excellent"
	6. *Elements of design:* 4 out of 4 rated the design "Excellent" as the details and embellishments are relevant to design
	Fit
	1. *Set:* 3 out of 4 rated "Excellent" and 1 rated as "Good"
	2. *Proper ease:* 2 out of 4 rated the ease of the design "Excellent" and 2 rated as "Good"
	3. *Hang of garment:* 4 out of 4 believed the hang of the garment was "Excellent"

DESIGN 6 Method: Transformational Reconstruction 	**Appearance**
	1. *Zero-waste look or not?* 3 out of 4 respondents believed that the design does not look zero-waste.
	2. *Visual aesthetic:* 3 out of 4 rated the visual aesthetic of the design "Excellent" and 1 rated as "Good"
	3. *Unity of design:* 4 out of 4 rated the design "Excellent" in cohesiveness
	4. *A single strong focal point:* 2 out of 4 rated this feature "Excellent" and 2 as "Good"
	5. *A means of transfer of interest:* 3 out 4 rated as "Excellent" and one as " Weak"
	6. *Elements of design:* 2 out of 4 rated the design "Excellent" as the details and embellishments are relevant to design; and 2 rated as "Good"
	Fit
	1. *Set:* 3 out of 4 rated "Excellent" and 1 rated as "Good"
	2. *Proper ease:* 2 out of 4 rated the ease of the design "Excellent" and 2 rated as "Good"
	3. *Hang of garment:* 3 out of 4 believed the hang of the garment was "Excellent" and 1 rated as "Good"