Design for Many, Design for Me: Universal Design for Apparel Products

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ABSTRACT   This study examined the potential of universal design in the field of apparel. The particular purpose of the study was to explore the use of the concept and principles of universal design as guidance for developing innovative design solutions that accommodate 'inclusivity' while maintaining 'individuality' regarding the wearer's

aesthetic tastes and functional needs. To verify the applicability of universal design in apparel products, two case studies of design practice were conducted, and the principles of universal design were evaluated through practical applications. This study suggests that universal design provides an effective framework for the apparel design process to achieve flexible and versatile outcomes. However, due to product proximity to the wearer, modification of the original definition and principles of universal design must be considered in applications for apparel design.

KEYWORDS: universal design, apparel product design, practical applications

Introduction

Universal design is defined as 'the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design' (Mace, 1985). The term universal design has been used interchangeably with other terms, such as inclusive design, design for all and barrier-free design, to denote design approaches that imply democratization and social inclusion (Knecht, 2004; Ostroff, 2001; Steinfeld and Maisel, 2012). Regardless of the terminology, practitioners recognize the original seven principles of universal design (see Table 1) developed in the late 1990s by the Center for Universal Design at North Carolina State University (Center for Universal Design, 2012). The seven principles included *equitable use*, being useful/marketable to people with diverse abilities; *flexibility in use*, accommodation of a wide range of individual preferences and abilities; *simple and intuitive to use*, easy to understand regardless of skill/knowledge level; *perceptible information*, communicates necessary information effectively to the user despite abilities and outside influences; *tolerance for error*, minimizes hazards from accidental or unintended actions; *low physical effort*, can be used efficiently and effectively with minimum fatigue; and *size/space for approach and use*, adequate size and/or space provided for manipulation regardless of body size, posture, or mobility (Clarkson *et al*, 2003). Designers may choose to adopt all or some of the principles to evaluate existing designs, guide the design process and mutually educate other designers and users about the benefits of universally designed products (Center for Universal Design, 2012). Although scholars have agreed that the principles of universal design constitute a valuable attempt to facilitate practice of the design philosophy in various design applications, they have also pointed out a need to clarify the concept further and provide more explicit guidelines for designers (Steinfeld and Maisel, 2012).

In the field of apparel, only a few empirical cases have applied the concept of universal design to their design practices (Carroll and Gross, 2010; Carroll and Kincade, 2007; Martins and Martins, 2012). Martins and Martins (2012) detailed each of the seven principles and identified areas in which apparel products can be improved by universal design. These studies tended to focus on design for a narrow segment of the population with physical disabilities. Vanderheiden and Vanderheiden (1992) suggested that, in some cases, the design of a product that is more accessible to people both with and without physical disabilities contributes to reducing the cost involved in manufacturing, altering or maintaining a product and enabling functionality for users without special needs, including benefits such as increased comfort. However, few or no attempts have been made to practise the concept and principles of universal design to serve a large number of end-user needs for apparel products.

This dearth of research is understandable given the unique nature of apparel products. Apparel products are valued as symbols of individuality that contribute to the construction of a person's appearance by reflecting the wearer's own style and aesthetic tastes; they act as a visual presentation of the wearer's identity (Eicher and Roach-Higgins, 1992). Mittal (2006) argued that consumers develop bonds with products after using them as part of their daily routines and eventually may come to consider the products to be part of their identity, which they in turn use to display their identity to others. Furthermore, apparel must conform to a person's physical individuality imposed by age, weight, gender, body shape and life stage while also meeting practical needs for protection from the environment. Therefore, this study aims to explore the use of the concept and principles of universal design as guidance for developing innovative design solutions that accommodate 'inclusivity' while maintaining 'individuality' reflecting the wearer's aesthetic tastes and functional needs. The study is intended to demonstrate the applicability of universal design principles in the apparel product development process and suggest further modifications of the design principles to enhance the communicability of universal design in the field of apparel. In the following section, we review cross-cultural and contemporary examples of the universal design philosophy in the context of apparel. We then discuss the concept of universal design in the continuum of leading-edge design paradigms to map out the present and future stance of universal design in the design discipline.

Universal Design in the Context of Apparel

The concept of universal design has been widely used in various design disciplines to generate products and environments with better accessibility and usability for a broad range of end-users, in particular, those previously excluded or denied access by inappropriate design (Clarkson *et al*, 2003). For example, design strategies in the built environment have explored ways to create residential

Table 1 Universal design principles and possible design solutions for apparel

	Design principles	Guidelines	Design solutions
1	**Equitable use** The design is useful and marketable to people with diverse abilities.	**1a.** Provide the same means of use for all users: identical whenever possible; equivalent when not. **1b.** Avoid segregating or stigmatizing any users. **1c.** Provisions for privacy, security, and safety should be equally available to all users. **1d.** Make the design appealing to all users.	Relaxed silhouette that fits a wide range of consumers of different sizes and shapes.
2	**Flexibility in use** The design accommodates a wide range of individual preferences and abilities.	**2a.** Provide choice in methods of use. **2b.** Accommodate right- or left-handed access and use. **2c.** Facilitate the user's accuracy and precision. **2d.** Provide adaptability to the user's pace.	Versatile way of dressing.
3	**Simple and intuitive use** Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.	**3a.** Eliminate unnecessary complexity. **3b.** Be consistent with user expectations and intuition. **3c.** Accommodate a wide range of literacy and language skills. **3d.** Arrange information consistent with its importance. **3e.** Provide effective prompting and feedback during and after task completion.	Easy donning and doffing.
4	**Perceptible information** The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.	**4a.** Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information. **4b.** Provide adequate contrast between essential information and its surroundings. **4c.** Maximize 'legibility' of essential information. **4d.** Differentiate elements in ways that can be described (i.e. make it easy to give instructions or directions). **4e.** Provide compatibility with a variety of techniques or devices used by people with sensory limitations.	Easy to understand the dressing procedure. Simple yet thoughtful design. Minimal design details.
5	**Tolerance for error** The design minimizes hazards and the adverse consequences of accidental or unintended actions.	**5a.** Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded. **5b.** Provide warnings of hazards and errors. **5c.** Provide fail safe features. **5d.** Discourage unconscious action in tasks that require vigilance.	Design that does not hinder body movement. Optimized fit for size flexibility.

	Design principles	Guidelines	Design solutions
6	**Low physical effort** The design can be used efficiently and comfortably and with a minimum of fatigue.	**6a.** Allow user to maintain a neutral body position. **6b.** Use reasonable operating forces. **6c.** Minimize repetitive actions. **6d.** Minimize sustained physical effort.	Easy donning and doffing and easy maintenance.
7	**Size and space for approach and use** Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.	**7a.** Provide a clear line of sight to important elements for any seated or standing user. **7b.** Make reach to all components comfortable for any seated or standing user. **7c.** Accommodate variations in hand and grip size. **7d.** Provide adequate space for the use of assistive devices or personal assistance.	Flexible size and fit. Easy donning and doffing.

and commercial spaces that accommodate the diverse needs of large numbers of people (Leibrock and Terry, 1999). In education, universal design has been implemented to identify effective instructional strategies for learners of all ages and abilities (Burgstahler, 2008), by enhancing accessibility of new modes of instructional technologies (e.g. distance learning) for students with learning disabilities (Burgstahler, 2008; Kmatsu *et al*, 2011; Siu and Lam, 2012). Moreover, product developers have incorporated universal design principles in developing products that appeal to a larger group of consumers (Trost, 2005).

The term universal design is relatively new in the apparel field. However, a cross-cultural investigation of ethnic dresses revealed that humans have used this democratic design concept in garments since the Old Stone Age, when the form of draped skirts and cape-like garments was constructed to fit the human body (Tortora and Eubank, 2006). In the contemporary setting, scholars have developed process models to guide the creation of apparel products. A review of previous scholarly work, which will be presented in the following section, provided valuable insights into positioning the paradigm of universal design in the existing body of knowledge in apparel product development.

Cross-cultural perspective

The concept of universal design extends the lifetime of the garment by transformation through the wearer's lifespan while retaining and reflecting a sense of personal and cultural identity. One familiar example is the Japanese kimono, which is constructed in such a way that it is adjustable from childhood through adulthood, economical in its use of materials and versatile in appearance. The kimono is made from one bolt of cloth, utilizing minimal cutting and sewing

(Van Assche, 2005). The easy fit afforded by the drape allows the kimono to fit anyone from a man, to a child, to a pregnant woman, exemplifying the universal design principles of *equitable use*, *flexibility in use*, *tolerance for error*, and *size and space for approach and use* (refer to Table 1). Excess fabric may be drawn up, folded and secured with a cord and obi sash to adjust for short stature. The kimono may be layered for warmth or made more utilitarian by tying back the sleeves with the cord. Other examples of garments that share these qualities include the Indian sari, Roman *toga*, Guatemalan *huipil* and *corte*, Saudi Arabian *zabun*, *sidriyya* and *midawwara*, and Ghanaian *adinkra* and *kente* (Gillow, 2001; Lindisfarne-Tapper and Ingham, 1997). These garments seem to adhere to most principles of universal design, but the principles including *simple and intuitive use*, *perceptible information* and *low physical effort* might be perceived as challenging to the wearer at first, especially when the wearer is not familiar with the garment. That is, how to wear these garments and harness their communicative power may not be immediately evident to the novice wearer, such as a child. Historical evidence, however, shows that these obstacles have been overcome by teaching children from a young age how to don and doff the vestments (Boulanger, 1997).

Since seaming techniques were first introduced to garment construction in the early Mesopotamian civilization (Tortora and Eubank, 2006), the pre-shaped style of garments (i.e. tailored to fit the wearer's body) has dominated the draped style; consequently, inclusiveness with body shaping of draped garments had to lend its popularity to tailored garments. Of note, technology advancement in tailoring has created contradictory outcomes of universal design within the context of apparel.

Contemporary apparel product development perspective

Scholars (Gam *et al*, 2008; LaBat and Sokolowski, 1999; Lamb and Kallal, 1992; May-Plumlee and Little, 1998; Watkins, 1988) have proposed various product development processes for apparel products. Regardless of the names and number of stages, all have agreed that certain elements in the processes are consistent. Common elements in the process of apparel product development include the following stages: needs assessment and research, creative exploration, prototyping, design evaluation and confirmation. The first stage of the process, needs assessment and research, is the most salient stage among the five stages for the product developer or designer to take time to investigate end-user needs and preferences for the target product (Rosenblad-Wallin, 1985). This stage involves gathering raw data of user needs and establishing the relative importance of these needs for design practice. Even though the end-user may not always be able to fully articulate his or her latent needs, the information retrieved from the end-user helps the product developer

build an understanding of the user's environment and point of view (Ulrich and Eppinger, 2008). The creative exploration stage follows, which requires generating as many preliminary design ideas as the designer can and then imposing constraints in the process of idea refinement (LaBat and Sokolowski, 1999). The aim of prototyping (also known as first sampling) is materialization of the design idea to see whether the sampled prototype demonstrates the desired level of product functionality and quality (Ulrich and Eppinger, 2008). Next, the evaluation stage demands substantial creative input to the prototype, as it is examined and revised (LaBat and Sokolowski, 1999). Finally, the confirmation stage occurs after the prototype is approved. The final product is presented to the end-user and the end-user decides whether to accept or reject the product in the marketplace (Keiser and Garner, 2008).

In an attempt to create apparel products utilizing the principles of universal design, Carroll and Gross (2010) stressed the need to create clusters of consumers with similar physical disabilities, rather than applying the 'ideal' concept of universal design for all end-users. The researchers proposed a circular model of apparel product development adapted from the original model set forth by Carroll and Kincade (2007). It consisted of five stages, including establishing end-user needs, sketching and making a prototype and generating a specification sheet, testing user and evaluator wear opinions, evaluating production feasibility and marketing feasibility, and implementing and communicating. In this model, the principles of universal design were posited in the third stage of the model, testing user and evaluator wear opinions. Carroll and Gross (2010) expanded the scope of universal design as an alternative design strategy, and their process model is more inclusive than other process models for apparel product development. Thus, we have argued that several components should be further considered to better integrate the principles of universal design into the development process of apparel products.

The seven principles of universal design may provide key considerations for the development of universally designed apparel products. Although Carroll and Gross's (2010) process model proposed considering the principles of universal design in the user wear testing stage, lack of sufficient explanation kept the audience from understanding the justification for the principles of universal design within the model. One may infer that Carroll and Gross's model suggests the principles of universal design as evaluation criteria for functionality in the wear testing phase. We suggest that the principles of universal design should be considered throughout the entire process of apparel product development, not just in one or two particular stages. The design principles need to be contemplated as underlying goals for the development of apparel products from the initial needs assessment and research stage to confirmation of the final design.

Universal Design in a Continuum of Contemporary Design Paradigms

Universal design is a process that enables and empowers a diverse population by recognizing user needs and offering products and services developed from a human-centred perspective (Steinfeld and Maisel, 2012). Universal design, emerging from the disability rights movement, seeks design solutions by giving more power to end-users. Today, design culture is evolving, and design paradigms have emerged to solve social problems in which the design focus has shifted from an increase in profits to enhanced quality of human life. Contemporary design paradigms with a close relationship to universal design include sustainable design, slow design, co-design and product personalization. These paradigms are undeniably related and significantly influence contemporary design.

Sustainability and universal design

The sustainable design movement has created new opportunities to explore and develop new approaches and re-evaluate the theoretical stance of design by including social equity (Fuad-Luke, 2004). One such opportunity is the application of universal design in apparel products to create sustainable outcomes. The key challenge of sustainable design for apparel products is to minimize the impact of production and consumption for the future preservation of the planet (Mackenzie, 1991). Within the sustainability movement, there has been a shift from overconsumption of apparel products to appreciation of thoughtful design and high quality (Dickson *et al*, 2009; Fletcher, 2007; Fletcher and Grose, 2012).

Sustainable design, in conjunction with universal design, has the ability to encourage the development of products with the principles of economic and ecological advancement in mind (Birkeland, 2002). Universal design arose from the need to address important contemporary social issues and a growing realization that design has much to offer in this regard (Coleman, 2006). As Coleman (2006: 24) explained, '… design itself had to change. It had to become population aware and people aware. [Design] therefore had to understand and address a much wider range of capabilities, more representative of the whole population.' Apparel products should address the emotional, expressive and physical qualities in garments that are desired by consumers (Hethorn, 2008; Holbrook and Hirschman, 1982). If the apparel industry is to sustain people, more attention must be paid to innovative design solutions that accommodate various consumer needs and will eventually lead to greater use and longer functioning style (Hethorn, 2008; Raunio, 1995). Furthermore, these design solutions must foster an emotional bond with the user, providing the consumer with 'profound and sophisticated user experiences that penetrate the psyche over time' (Chapman, 2005: 18). If wearers are emotionally invested in their apparel, then, as Soepboer said, sustainability will be a natural consequence achieved

by longevity of the product life cycle (Rahman, 2011). Then the fundamental enquiry of universal design will be justified as a sound start to sustaining people through flexible design with satisfying product experiences (Dickson *et al*, 2009; Hethorn, 2008).

Slow design and thoughtful consumption

Slow design is one solution that aims to counter overconsumption of apparel products. Slow design looks beyond the traditional model of free enterprise to consider sustainable awareness by refocusing on individual, cultural and environmental well-being and encouraging a long-term view in design principles (Clark, 2008; Fletcher, 2007; Fuad-Luke, 2009). Slow design is viewed as a counterbalance to the existing design paradigm of fast fashion, which glorifies inexpensive apparel products with a significantly shorter lifespan (Fuad-Luke, 2004). Slow design enables richer interaction among the designer, manufacturer and end-user than the traditional manufacturing process (Fletcher, 2007).

Strauss and Fuad-Luke (2008) proposed the principles of slow design as a new evaluation tool to guide design practices with a view to social, cultural and environmental sustainability. The principles include revealing experiences in everyday life that are often overlooked or forgotten in a product's existence or creation; expanding the perceived functionalities, physical attributes and lifespans of a product; reflecting on consumption; engaging collaborations and transparencies to evolve design in the future; participating in an active design process; and evolving into product maturation (Strauss and Fuad-Luke, 2008). By considering slow fashion ideals along with the current trend of universal design, the apparel industry can move beyond the framework to uncover new potential and critically examine current processes and motives.

Co-design as a universal design process

Co-design is a term that encompasses design paradigms such as participatory design, user-centred design and open design. It recasts people in roles other than those strictly of consumers (Fletcher, 2008; Fuad-Luke, 2009; Sanders and Stappers, 2008). Participatory design is not a single design method, but involves the following dimensions: (a) domains of human activity, (b) roles of stakeholders in the design process, (c) types of shared design representations, (d) scope and duration of participatory interactions and (e) relationships of end-users to design activity with respect to their knowledge and skill (Fletcher, 2008; Fuad-Luke, 2009; Sanders and Stappers, 2008). Co-design is built on the idea that those who will ultimately use the product should be involved in the design process. This will increase the overall quality of design and is enhanced by additional support from stakeholders (Fletcher, 2008).

For co-design to succeed, one must believe *all* people are creative and have valuable input (Bjorgvinsson, 2008; Sanders and Stappers,

2008). Consumers are moving away from purchasing products that offer short-term satisfaction and are starting to purchase products that will provide long-term fulfilment (Maxwell *et al*, 2006). People are looking for a balance between passive consumption and thoughtful creative experiences (Bjorgvinsson, 2008; Sanders and Stappers, 2008). Co-design allows for and encourages product development across multiple disciplines and creates products that will withstand time. Through collaboration between the designer and consumer, co-design is able to focus not only on the product itself, but also on the positive experience that the product encompasses (Chapman, 2005; Sanders, 2006).

Co-design can be executed in a variety of ways. The fragmented textiles of Dutch designer Berber Soepboer are composed of diamond shapes that can be snapped together by the user to form an infinite number of customizable ensembles (Rahman, 2011; Soepboer, n.d.). Soepboer's 'Colour-In Dress' demonstrates co-design of the textile rather than the entire garment form; the dress features a black-and-white textile print that wearers are encouraged to colour in to fit their needs (Rahman, 2011; Soepboer, n.d.). Japanese designer Issey Miyake encourages co-design in his A-POC ready-to-wear line of clothing. A-POC, which stands for 'a piece of cloth', features variable clothing ensembles that are engineered together in a single tube of cloth. The wearer cuts out the garment from the fabric and is able to transform the garment with each further cut (English, 2011). In interviews, both Soepboer and Miyake have expressed how wearers are empowered by their involvement in the design process (English, 2011; Rahman 2011). As Miyake said, 'You can wear it as you like – they're your clothes' (English, 2011: 15). Halfway design also features a similar concept of user participation in the design process. Fuad-Luke (2009) explained that in a halfway product, the designer leaves a space for the user to complete the making as a means of expressing his or her own creativity, stories and mistakes in the process of finishing the product. Co-design when applied to universal design can create products that are more appropriate for a larger group of people. Incorporating users who typically have been excluded from the design process likely broadens the scope of potential users.

Product personalization as a universal design alternative

Product personalization has been defined as 'a process that changes the functionality, interface, information content or distinctiveness of a product to increase its personal relevance to an individual' (Blom, 2000: 313). Product personalization provides flexibility within mass customization, which offers users the ability to customize products and services to individual consumers of niche markets on a large scale without losing the benefits of mass production (MacCarthy, 2003). The result of the personalization process is that consumers

obtain a product suited to their needs and tastes. By personalizing a product, consumers direct time, effort and attention to the product, which can increase their level of attachment and usability (Mugge *et al*, 2004).

Influencing the degree of attachment through product personalization can be valuable. From the viewpoint of environmental sustainability, a stronger emotional bond with a product will decrease the consumer's tendency to dispose of it (Mugge *et al*, 2004). Product personalization takes into consideration a socially responsible ethos and creates an environment of designing for end-users. Personalizing the functionality and/or form of a product can increase the value offered and broaden the range of consumers interested in its design (Coleman, 2006; Mugge *et al*, 2004). Product personalization can be achieved through a demographic design approach such as co-design, whereby the end-user's voice informs the design process (Fuad-Luke, 2009).

As DeLong *et al* (2005) pointed out, today's apparel products are more about helping individuals build their own identities than relying on a universal standard. It is challenging to create an apparel product that can be utilized by all members of society because it creates a risk of dehumanizing the individual end-user or wearer, not allowing the display of the wearer's identity. Varying individual body sizes and shapes, cultural backgrounds and aesthetic preferences make the archetypical practice of universal design seemingly impossible in the context of apparel design. However, the researchers in this study understand that the goal of universal design, particularly in designing apparel products, is to offer flexible, customizable options to as many end-users as possible, including those who have been excluded from design considerations in the past. That is, these products have to be developed through creative thinking and best practices as a counterbalance to design exclusion.

Practice of Universal Design for Apparel Products

To verify the applicability of universal design in apparel product development, two practices of apparel design were performed with embedded considerations of universal design. The first was a faculty-student design team (i.e. the authors of this paper participated in the design practices). The design team consisted of three students majoring in design (two graduates and one undergraduate) and a faculty member in a US, four-year apparel design program. The design practices were collaboratively planned and created through numerous discussions and contemplations to apply and evaluate the principles of universal design. During the design processes, we repeatedly referred to cross-cultural and contemporary examples of apparel cases and sought design solutions to accommodate a wide range of wearers by enhancing versatility, flexibility and usability of the designed outcomes, while still offering aesthetic appeal.

Figure 1
Design One: Pupa Butterfly.

The first design (Figure 1), *Pupa Butterfly*, is a tunic dress with an optional support belt for women in the transitional life stage of pregnancy and beyond. The second design (Figure 2), *Inkjet Paintbrush*, consisting of a scarf blouse and a high-waist skirt, is an ensemble for women who are not necessarily pregnant, but who go through changes in body shape and size over the life course or for a wide range of female consumers with different body types.

Figure 2
Design Two: Inkjet Paintbrush.

Design One: **Pupa Butterfly**

The inspiration for the first design was to create a women's apparel product for the transitional life stage of pregnancy to motherhood. The transition to motherhood is a period of dramatic social and physical changes in women's lives. After the birth of a child, most women likely experience a slow return of their body to its pre-pregnancy state, or they may have permanent body size/shape changes (Jenkin and Tiggemann, 1997). Additionally, the physical reality of childbearing is considered by some women in this transitional life stage to be incongruent with the standard of aesthetic beauty in the Western culture (Greer, 1984). Despite this belief, many women still aspire to look attractive while they are going through this transitional life stage.

The key design elements identified above provided guidance to creative design ideations. A tunic dress (Figure 3) was created with intrinsic versatility so the wearer may customize the dress silhouette
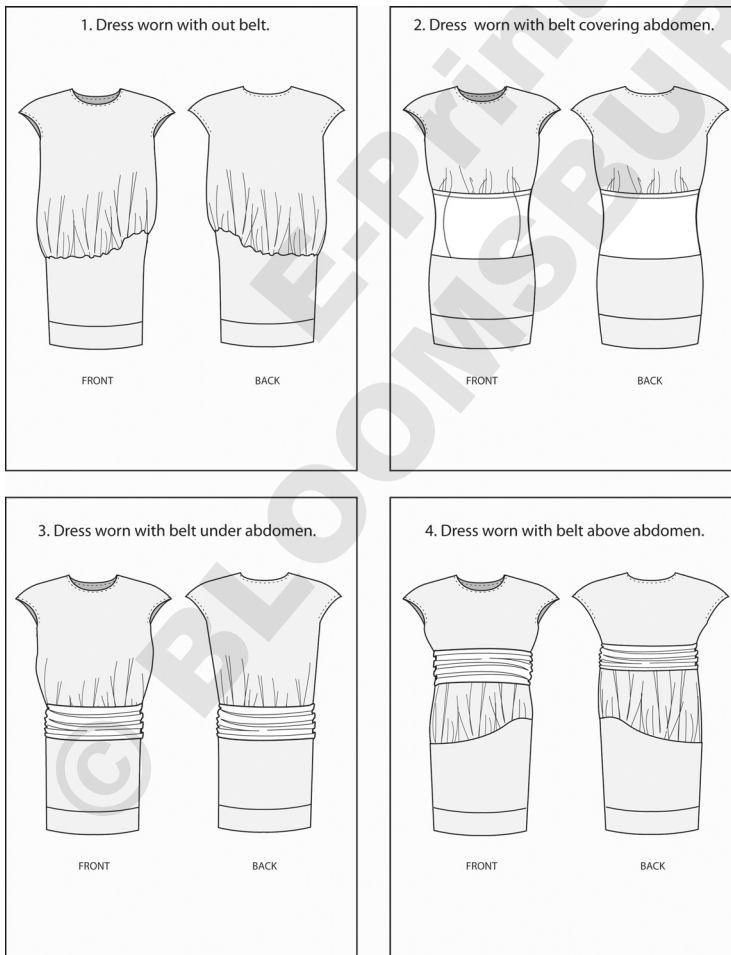

Figure 3
Dressing variations for Pupa Butterfly.

by wearing the optional belt, changing the way the belt is worn on the dress, and reversing both the dress and the belt from an abstract print to a solid coloured fabric. Inspired by the metamorphosis of butterflies, colourful butterfly motifs and watercolour strokes were used for the textile design as a means to visually depict the most celebratory stage of life for women. The textile design was digitally printed on the Lycra jersey-blend fabric. The creative exploration stage involved generating multiple design ideas using as many universal design principles as possible. The design team critically examined each design idea. A tunic dress and a support belt were ultimately chosen for the prototype. Design elements such as relaxed fit, shirring details, elastic fabric choices and reversibility with no determined front/back and opening were included to fulfil the universal design principles for women's clothing. Once the design was finalized, a prototype was created and design evaluation followed. The fitting of the initial prototype found that the fabric stretch and weight were important to the drape of the garment, and initial design features, such as a drawstring at the hemline, were removed. The design team generated and evaluated a second prototype before confirming the final design.

At the onset of the design process, the seven principles of universal design were carefully examined. For this particular design case, five principles out of the original seven applied. The principles considered pertinent to the practice of this design problem included *equitable use*, *flexibility in use*, *simple and intuitive to use*, *low physical effort* and *size and space for approach and use*. This versatile and inclusive design allows the wearer to customize the look of the apparel product, playing with various design options in fabric colour/ pattern and silhouette and also to change the fit as she experiences size and body shape changes throughout the course of her pregnancy. We believe this outcome meets the criteria for the first design principle, *equitable use*. The *flexibility* in expression and customization of the silhouette and colour/pattern combination also offers the wearer opportunities to create multiple expressions of self through the designed product.

Simple and intuitive use was also reflected in the minimalistic silhouette of this tunic dress, since it allows the wearer to easily discern how it needs to be worn. The indeterminate front and back of the design limit confusion and fault while dressing. The belt accessory is simple in design for the same reason. Not only does the belt provide the ability to manipulate the silhouette, but it also acts as a functional support accessory to provide the wearer with the desired support and compression during her pregnancy. This dress was designed to easily don and doff with *low physical effort*. For example, the Lycra jersey fabric allows for ample stretch and ease in putting the garment on and taking the garment off and the fabric and construction do not restrict movement while wearing the tunic dress, nor are there any fasteners that may be hard to reach when the wearer is close to term.

This design also provides adequate size to accommodate many different body shapes, which fulfils the principle of *size and space for approach and use*. Regardless of the body size before, during or after pregnancy, the dress will be wearable because of the fabric construction and fibre content, as well as the unconstrained silhouette. The emphasis of this design concept was to provide the wearer with as much versatility, flexibility and personalization as possible. This design goal was achieved through reversibility and silhouette manipulation. Because the wearer, at no extra cost, can customize the dress into more than six different looks, one may argue that universal design can extend the product lifespan when the wearer participates in the customization of garments (Fletcher, 2007; Fletcher and Grose, 2012). Self-congruity through the design can enhance wearing pleasure and extend product lifespan (Chang *et al*, 2009; Sirgy, 1985).
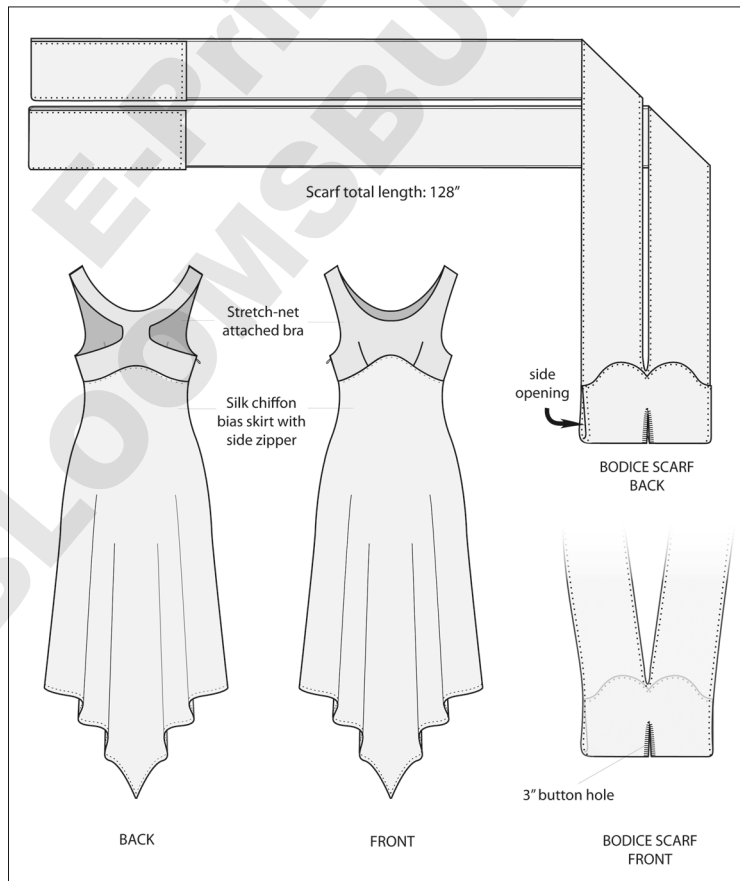
Design Two: Inkjet Paintbrush

The second design was intended to explore design options to accommodate various body shapes and sizes with a single garment through a silhouette-shaping technique called draping. This technique is considered to be the only pattern-making system that relies on fabric and a three-dimensional dress form (i.e. a replica of the human body) in creating a design (Joseph-Armstrong, 2008). Therefore, draping requires the designer's comprehension of the human body and skilful handiwork in the design since the conceptual design ideas are materialized in a three-dimensional form. This technique is often used in couture design for high-end consumers because it allows the designer to interact with the actual fabric to be used, as well as the actual body size and shape of the wearer (Amaden-Crawford, 2012). Inspired by and reinterpreting Madeleine Vionnet's bias-cut draping techniques for the contemporary mass market, this dress was created to accommodate the desired fit and look for a range of consumers with various body sizes and figures.

A variety of body shapes and measurements exist within the current industry sizing system for apparel products, and potential design adjustments are desired to increase consumer acceptance of fit (Ashdown *et al*, 2004; Connell *et al*, 2003). As for the design process, this dress adopted an artistic process of creative design exploration. An original oil painting on 3' × 5'canvas, painted by one of the designers, was photographed and translated into an electronic file. Using textile computer-aided design (CAD) software, the oil painting was transformed into a sophisticated textile design. This design process allowed the designers to experiment with various design manipulations in colour, proportion, repeats and overlay in a much shorter time than in the traditional design process. For this particular textile design, a transparent image of the original oil painting was mirrored and overlaid onto each layer. Numerous colour combinations and repeat effects were explored before the final

design was achieved. Taking Vionette's original pattern No. 8 (Kirke, 2005) as a cue for the final design idea, a silk chiffon dress was draped and the patterns were digitized. Digitization of the patterns was necessary to translate the couture draping technique into the mass production process, allowing repetitive duplications of the pattern for mass production. Then a prototype was created so that the fit and silhouette of the assembled first sample could be evaluated on a dress form. The design team suggested slight alterations and then confirmed the final design.

The principles of universal design were contemplated and incorporated into every stage of the design process. This garment consisted of a high-waist dress and a scarf (40" × 130"), draped on a standardized dress form of size 8. The scarf was designed to be wrapped around the upper torso and the double-layered edge of the scarf created a loop to hold the long piece of the fabric at the under-bust line (Figure 4). Along with a buttonhole at the center front, the loops function as fasteners for the scarf drape to maintain the dress shape. This innovative draping solution emphasized the

Figure 4
Technical sketch of Inkjet Paintbrush.

Scarf total length: 128"

Stretch-net attached bra

Silk chiffon bias skirt with side zipper

side opening

BODICE SCARF BACK

3" button hole
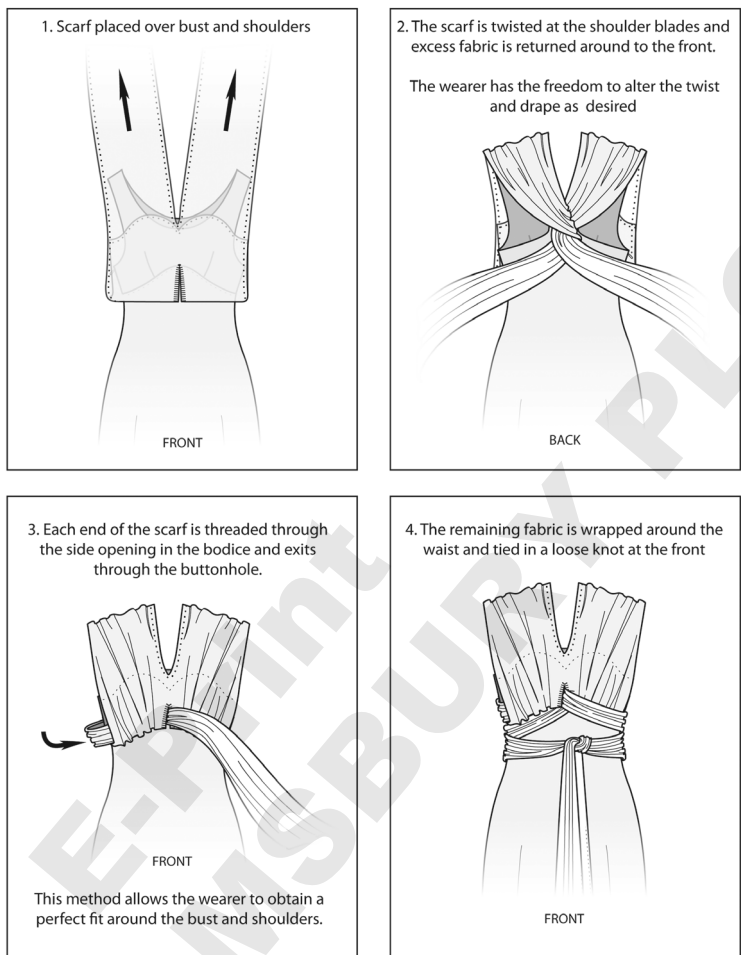
BACK

FRONT

BODICE SCARF FRONT

uniqueness of the dress and provided high flexibility and versatility to wearers of diverse body sizes and shapes, which met the criteria for the first two principles of universal design, *equitable use* and *flexibility in use*. In addition, the chiffon scarf allowed the wearer a visual way to express her aesthetic preferences by exploring various ways of wrapping the scarf around her torso. No matter how she wraps the scarf, the created look is still guaranteed to be acceptable. This fulfils the principle of *tolerance for error*. Furthermore, the undetermined body shaping of the scarf allows the wearer to experiment with a range of fittings around the body, either loose or fitted, depending on the wearer's wrapping methods. Such an adaptable design feature fulfils the principle of *size and space for approach*. The design team noticed that putting on the scarf top was not instantly obvious to the wearer. As a result, the stretchy mesh bodice attached to the high-waist skirt was further intended to provide guidance for easy dressing, which suggested better solutions for *simple and intuitive use* and *low physical effort*.

The principle of *perceptible information* for both designs was evaluated through participation in an international juried design exhibition. Prior to the exhibition, the dresses were shipped along with the dressing instructions (refer to Figure 5 for the dressing instructions for Inkjet Paintbrush) for exhibition staff. The staff members, who did not have previous knowledge of the dresses, informed the authors that they were able to assemble the designs correctly, which lends a degree of support for the achievement of the design principle of *perceptible information*. However, actual wearers should be invited to evaluate this principle because exhibition staff members are usually trained personnel who have a relatively high level of understanding of how garments work.

Discussion and Conclusion

This study evaluated the applicability of the universal design principles in apparel product development. Ideally, universal design pursues the full inclusion of users; the utopian goal of universal design is the creation of products for all. However, due to the product proximity of apparel to the wearer, we recognize that the practice of universal design in apparel should consider a more demographic approach. Given the fundamental uniqueness of apparel products, we found, in general, that the original principles of universal design were compatible with design considerations for apparel products. For example, the design cases in this study proved that the principles of universal design are generally applicable to apparel products. That is, design features of easy donning and doffing, unstructured silhouette, generous fit and versatile yet minimalistic look fulfil the universal design principles. However, the pertinence of some principles, such as *simple and intuitive use*, *perceptible information* and *low physical effort* should be further examined. Especially when an apparel product displays non-traditional features (i.e. innovative

Figure 5
Donning instructions for
Inkjet Paintbrush.

1. Scarf placed over bust and shoulders

FRONT

2. The scarf is twisted at the shoulder blades and excess fabric is returned around to the front.

The wearer has the freedom to alter the twist and drape as desired

BACK

3. Each end of the scarf is threaded through the side opening in the bodice and exits through the buttonhole.

FRONT

This method allows the wearer to obtain a perfect fit around the bust and shoulders.

4. The remaining fabric is wrapped around the waist and tied in a loose knot at the front

FRONT

design ideas), at the initial introduction stage, the wearer tends to go through the adaptation process to familiarize himself or herself with the product. For example, in the case of Inkjet Paintbrush, although the design outcomes fulfilled the rest of the universal design principles, due to its unique, unconventional donning suggestion, such communication-related principles have not been fully confirmed. This finding is also consistent with insights from the cross-cultural examples discussed in the literature review. This study suggests that the wearer's cognitive process of design adaptation needs to be further studied in an experimental setting.

Recently, Steinfeld and Maisel (2012) suggested eight goals of universal design to improve the communicability of universal design in design practices; these goals include body fit, comfort, awareness, understanding, wellness, social integration, personalization and cultural appropriateness. They claimed that these eight goals are concise and measurable and also aligned with the original universal

design principles. According to their argument, the principles of simple and intuitive use and perceptible information can both be achieved through an understanding and awareness of user needs, cultural appropriateness and health and wellness, and additionally the concept of perceptible information requires assurance that critical information for use is easily perceived. They also suggested that the aspect of low physical effort can be pursued by focusing on design opportunities for personalization, cultural awareness and comfort. Steinfeld and Maisel (2012) developed an organizational culture to help implement universal design in practice; however, definitions of the eight goals are still not explicit and measurable, and the goals are not thoroughly explained. We believe that the validity of these new goals should be further evaluated and compared with the outcomes of the original principles of universal design.

With an emphasis on addressing the principles of universal design for apparel design, we have discerned the interwoven relationships of universal design with the other design paradigms mentioned in the literature review. That is, the contemporary design paradigms, including universal design, sustainable design, slow design, co-design and product personalization, likely create a seamless crossover from one concept to another. As Niinimaki and Koskinen (2011) asserted, the promotion of deeper consumer product satisfaction often results in long-term product relationships. Therefore, when the consumer is satisfied with the quality and performance of a product, he or she is likely to use it and be emotionally attached to it for a longer time, thereby meeting the criteria for sustainable design (Chapman, 2005; Fletcher and Grose, 2012). Universal design is the design endeavour that recognizes the importance of understanding user needs, and co-design, which is an active form of user inclusion in the design process, promises the achievement of desired outcomes of universal design. Additionally, improvement of product quality through a thoughtful design process will enhance consumer satisfaction. Although it may slow the design process (slow design), revalidation of design ideas through evaluation of consumer needs and preferences (product personalization) is highly recommended.

The evaluation methods in the present study relied on the researchers' subjective criteria for determining the applicability of universal design; therefore, alternative evaluation strategies to draw on objective perspectives should be applied in future research. The findings of the present study are limited to two empirical cases by four designers. However, based on the experience through the design process, we observed that different design ideas can be generated by designers with different backgrounds, skills and resources. Most importantly, this study provides further empirical evidence of the use of universal design in apparel product creation. This study proved that the practice of universal design for apparel products may not comply with the motto of 'design for all', but is instead the act of 'design for many', offering flexible fit and sizes to as many wearers

as possible. It is also 'design for me', providing versatile ways of dressing to express the wearer's individuality through various ways of wearing and shaping. Furthermore, the findings show that the concept and principles of universal design in the design process of apparel products are an effective framework to encourage designers to explore their creativity and critical thinking skills in finding innovative design solutions for flexible and versatile apparel products. We hope that this study builds further awareness and an increased focus on the concept of universal design in the field of apparel.

References

Amaden-Crawford, C. (2012). *The Art of Draping*. New York: Fairchild Publications.

Ashdown, S. P., Loker, S., Schoenfelder, K. A. and Lyman-Clarke, L. (2004). 'Using 3D scans for fit analysis'. *Journal of Textiles and Apparel, Management and Technology*, 4(1). Available at: http://www.tx.ncsu.edu/jtatm [accessed 10 February 2011].

Birkeland, J. (2002). *Design for Sustainability: A Sourcebook of Integrated, Eco-logical Solutions.* London: Earthscan.

Bjorgvinsson, E. B. (2008). 'Open-ended participatory design as prototypical practice'. *CoDesign*, 4(2): 85–99.

Blom, J. (2000). 'Personalization – a taxonomy'. In *Proceedings of the CHI 2000 Conference on Human Factors in Computing Systems*, The Hague, The Netherlands, pp. 313–314.

Boulanger, C. (1997). *Saris: An Illustrated Guide to the Indian Art of Draping*. New York: Shakti Press International.

Burgstahler, S. E. (2008). 'Universal design of instruction: From principles to practice'. In Burgstahler, S. E. and Cory, R. C. (eds), *Universal Design in Higher Education: From Principles to Practice.* Cambridge, MA: Harvard Education Press. pp. 23–44.

Carroll, K. E. and Gross, K. (2010). 'An examination of clothing issues and physical limitations in the product development process'. *Family and Consumer Science Research Journal*, 39(1): 2–17.

Carroll, K. E. and Kincade, D. H. (2007). 'Inclusive design in apparel product development for working women with physical disabilities'. *Family and Consumer Sciences Research Journal*, 35(1): 289–315.

Center for Universal Design (2012). *The Principles of Universal Design*. Available at: http://www.ncsu.edu/www/ncsu/design/sod5/cud/about_ud/udprinciples.htm [accessed 1 November 2012]

Chapman, J. (2005). *Emotionally Durable Design: Objects, Experiences and Empathy*. London: Earthscan.

Chang, C., Chen, H. and Huang, I. (2009). 'The interplay between customer participation and difficulty of design examples in the online designing process and its effect on customer satisfaction: Mediational analyses'. *CyberPsychology and Behavior*, 12(2): 147–153.

Clark, H. (2008). 'Slow + fashion: An oxymoron or a promise for the future?' *Fashion Theory*, 12(4): 427–446.

Clarkson, J., Coleman, R., Keates, S. and Lebbon, C. (eds) (2003). *Inclusive Design: Design for the Whole Population.* London: Springer Verlag.

Coleman, R. (2006). 'From margins to mainstream: Why inclusive design is better design'. Paper presented at *The Ergonomics Society Annual Lecture*, April 2006. Available at: http://www.hhc.rca.ac.uk/CMS/files/ErgSocLecture06.pdf [accessed 3 November 2012].

Connell, L. J., Ulrich, P. V., Knox, A., Hutton, G., Trent, N. and Bruner, D. (2003). 'Body scan analysis for fit models based on body shape and posture analysis' (No. S01-AC27): National Textile Center. Available at: http://www.ntcresearch.org/pdf-rpts/AnRp03/S01-AC27-A3.pdf [accessed 3 November 2012].

DeLong, M., Heinemann, B. and Reiley, K. (2005). 'Hooked on vintage!' *Fashion Theory*, 9(1): 23–42.

Dickson, M. A., Loker, S. and Eckman, M. (2009). *Social Responsibility in the Global Apparel Industry.* New York: Fairchild Publications.

Eicher, J. B. and Roach-Higgins, M. E. (1992). 'Definition and classification of dress: Implications for analysis of gender roles'. In Barnes, R. and Eicher, J. B. (eds), *Dress and Gender: Making and Meaning*. Providence, RI: Berg, pp. 8–28.

English, B. (2011). *Japanese Fashion Designers: The Work and Influence of Issey Miyake, Yohji Yamamoto and Rei Kawakubo*. New York: Berg.

Fletcher, K. (2007). 'Slow fashion'. *Ecologist*, 37(5): 61. Available at: http://www.theecologist.org/green_green_living/clothing/269245/slow_fashion.html [accessed 3 November 2012].

Fletcher, K. (2008). *Sustainable Fashion and Textiles: Design Journey.* London: Earthscan.

Fletcher, K. and Grose, L. (2012). *Fashion and Sustainability: Design for Change*. London: Laurence King Publishers.

Fuad-Luke, A. (2004). *Slow.* Available at: http://slowdesign.org/pdf/Slowdesign.pdf [accessed 1 August 2011].

Fuad-Luke, A. (2009). *Design Activism: Beautiful Strangeness for a Sustainable World*. London: Earthscan.

Gam, H. J., Cao, H., Farr, C. and Heine, L. (2009). 'C2CAD: A sustainable apparel design and production model'. *International Journal of Clothing Science and Technology*, 21(4): 166–179.

Gillow, J. (2001). *Printed and Dyed Textiles from Africa.* London: British Museum Press.

Greer, G. (1984). *Sex and Destiny: The Politics of Human Fertility.* New York: Harper & Row.

Hethorn, J. (2008). 'Consideration of Consumer Desire'. In Hethorn, J. and Ulasewicz, C (eds), *Sustainable Fashion: Why Now?* New York: Fairchild, pp. 53–76.

Holbrook, M. B. and Hirschman, E. C. (1982). 'The experiential aspects of consumption: Consumer fantasies, feelings, and fun'. *Journal of Consumer Research*, 9: 132–140.

Jenkin, W. and Tiggemann, M. (1997). 'Psychological effects of weight retained after pregnancy'. *Women Health*, 25(1): 89–98.

Joseph-Armstrong, H. (2008). *Patternmaking for Fashion Design*. New York: Fairchild.

Keiser, S. J. and Garner, M. B. (2008). *Beyond Design: The Synergy of Apparel Product Development.* New York: Fairchild.

Kirke, B. (2005). *Madeleine Vionnet*. San Francisco, CA: Chronicle Books Editions.

Kmatsu, R., Tang, D., Obo, T. and Kubota, N. (2011). 'Multi-modal communication interface for elderly people in informationally structured space'. *Intelligent Robotics and Applications – Lecture Notes in Computer Science*, 7102: 220–228.

Knecht, B. (2004). 'Accessibility regulation s and a universal design philosophy inspire the design process'. *Architectural Record*, 192: 145–150.

LaBat, K. and Sokolowski, S. (1999). 'A three-stage design process applied to an industry-university textile product design project'. *Clothing and Textiles Research Journal*, 17(1): 11–20.

Lamb, J. M. and Kallal, M. J. (1992). 'A conceptual framework for apparel design'. *Clothing and Textiles Research Journal*, 10(2): 42–47.

Leibrock, C. A. and Terry, J. E. (1999). *Beautiful Universal Design: A Visual Guide.* New York: John Wiley & Sons.

Lindisfarne-Tapper, N. and Ingham, B. (eds) (1997). *Languages of Dress in the Middle East*. Richmond: Curzon Press.

MacCarthy, B. (2003). 'Weapon of choice'. *IEE Review*, 82(2): 43.

Mace, R. (1985). *Universal Design, Barrier Free Environments for Everyone*. Los Angeles, CA: Designers West.

Mackenzie, D. (1991). *Green Design: Design for the Environment*. London: Laurence King Publishers.

Martins, S. B. and Martins, L. B. (2012). 'Ergonomics, design universal and fashion'. *Work*, 41: 4733–4738.

Maxwell, D., Sheate, W. and van der Vorst, R. (2006). 'Functional and systems aspects of the sustainable product and service development approach for industry'. *Journal of Cleaner Production*, 14: 1466–1479.

May-Plumlee, T. and Little, T. (1998). 'No-interval coherently phased product development model for apparel'. *International Journal of Clothing Science and Technology*, 10(5): 342–364.

Mittal, B. (2006). 'I, me, and mine: How products becomes our extended selves'. *Journal of Consumer Behaviour*, 5(6): 550–562.

Mugge, R., Schifferstein, H. N. J. and Schoormans, J. P. L. (2004). 'Personalizing product appearance: The effect on product attachment'. In Kurtozu, A. (ed.), *Proceedings of the Fourth*

International Conference on Design and Emotion, May 2004, The Design and Emotion Society, Ankara, Turkey.

Niinimaki, K. and Koskinen, I. (2011). 'I love this dress, it makes me feel beautiful!: Empathic knowledge in sustainable design'. *The Design Journal*, 14(2): 165–186.

Ostroff, E. (2001). 'Universal design: The new paradigm'. In Preiser, W. and Ostroff, E. (eds), *Universal Design Handbook*. New York: McGraw Hill, pp 1.3–1.8.

Rahman, F. (2011). *A Fashion Odyssey – Premsela's Sustainable Fashion Assignment* [online video]. Available at: http://vimeo.com/26274832 [accessed 30 October 2012].

Raunio, A-M. (1995). 'Favorite clothes: A look at individuals' experience of clothing'. In Suojanen, U. (ed.), *Clothing and Its Social, Psychological, Cultural and Environmental Aspects, Proceedings of a Symposium on Textiles, Clothing and Craft Design*, Helsinki, 20 May 1995, pp. 179–194, Department of Teacher Education, Helsinki, Finland.

Rosenblad-Wallin, E. (1985). 'End-user-oriented product development applied to functional clothing design'. *Applied Ergonomics*, 16(4): 279–287.

Sanders, E. B. N. (2006). 'Design research in 2006'. *Design Research Quarterly*, 1(1): 1–8.

Sanders, E. B. N. and Stappers, P. J. (2008). 'Co-creation in the new landscapes of design'. *CoDesign*, 4(1): 5–18.

Sirgy, J. (1985). 'Using self-congruity and ideal congruity to predict purchase motivation'. *Journal of Business Research*, 13(1): 195–206.

Siu, K.W. M. and Lam, M. S. (2012). 'Public computer assisted learning facilities for children with visual impairment: Universal design for inclusive learning'. *Early Childhood Education Journal*, 40(5): 295–303.

Soepboer, B. (n.d.). *'Fragmented Textiles' in Collection*. Available at: http://berbersoepboer.nl/component/collections/#21 [accessed 3 October 2012].

Steinfeld, E. and Maisel, J. (2012). *Universal Design: Creating Inclusive Environments*. Hoboken, NJ: John Wiley & Sons.

Strauss, C. F. and Fuad-Luke, A. (2008). 'The slow design principles: A new interrogative and reflexive tool for design research and practice'. *Changing the Change, Design Vision Proposals and Tools*, pp. 1–14. Available at: http://www.slowlab.net/CtC_SlowDesignPrinciples.pdf [accessed 1 December 2012].

Tortora, P. and Eubank, K. (2006). *Survey of Historic Costume*. New York: Fairchild.

Trost, G. (2005). 'State of affairs in universal design in Europe'. *FUJITSU Science Technology Journal*, 41(1): 19–25.

Ulrich, K. T. and Eppinger, S. D. (2008). *Product Design and Development.* New York: McGraw Hill.

Van Assche, A. (ed.) (2005). *Fashioning Kimono: Dress and Modernity in Early Twentieth-Century Japan*. Milan: Woodbridge Publishers.

Vanderheiden, G. C. and Vanderheiden, K. R. (1992). 'Guidelines for the design of consumer products to increase their accessibility to people with disabilities or who are aging (Working Draft 1.7)'. *Research to Make Everyday Technologies Accessible & Usable …*, University of Wisconsin-Madison, Trace Research and Development Center. Available at: www.trace.wisc.edu/docs/consumer_product_guidelines/toc.htm [accessed 2 December 2012].

Watkins, S. (1988). 'Using the design process to teach functional apparel design'. *Clothing and Textile Research Journal*, 7(1): 10–14.

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