DEVELOPMENT AND IMPLEMENTATION OF A SUSTAINABLE APPAREL DESIGN AND PRODUCTION MODEL

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CHAPTER I

INTRODUCTION

Sustainable development is development that meets current needs without compromising future generations' welfare (World Commission on Environment and Development, 1987). From an industry perspective, sustainable development means that "the economic bottom line is congruent with improving social conditions and environmentally responsible manufacturing because (i) a motivated, healthy workforce living in a thriving community is more productive and (ii) using less resources, generating less waste, and improving quality reduces costs while increasing demand" (Mihelcic et al., 2003). William McDonough, an environmental architecture designer, and Michael Braungart, a green chemist, have suggested these environmental design guidelines, named "Cradle to Cradle," (McDonough & Braungart, 2002): 1) waste equals food, 2) employ current solar income, and 3) respect diversity. According to them, products should not be designed in a way that will drain resources, and hydrocarbon-fueled energy should be replaced by solar energy. The "Cradle to Cradle" model has been applied in areas such as engineering and footwear and interior design.

The apparel industry is a major contributor to environmental problems from textile material manufacture to apparel production to the saturation of landfills with synthetic fabrics. For example, the production of cotton is causing major environmental damage because a large quantity of pesticides, fertilizers, and defoliants are used in cotton fields. In 1999, cotton was the second most heavily pesticide-sprayed crop (behind only corn) with approximately 81 million pounds of pesticide applied to upland cotton in the US (Marquardt, 2001). Some of these chemicals are carcinogens and have severely contaminated the water supply. In manufacturing, the textile industry consumes a large quantity of water and generates large volumes of waste. On average, approximately 160 pounds of water (20 gallons) are required to produce 1 pound of textile product. Textile production is also a chemical-intensive industry. The wastewater from textile processing contains bath residues from preparation, dyeing, finishing, slashing, and other operations (U.S. Environmental Protection Agency, 1996).

As early as 1970, Victor Papanek saw the role designers could play to ease environmental problems. He said that in this age of mass production, designers have become the most powerful shapers of our work and environments (Papanek, 1971). Hakkio and Laaksonen (1998) examined the relationship among designers, manufacturers, and retailers. They concluded that designers have more responsibility for material selections and the making of products based on consumer need than manufacturers and retailers. Other research also found that more than 80% of the environmental impact of products is determined during the product design phase (M2 Presswire, 2005). However, according to Mackenzie (1997), in most institutions, design has not been taught in the context of its social and ecological impact. Many designers assume that their area of responsibility is limited to function and appearance.

Previous literature in the textile and apparel industry provides us with various types of apparel design and production models (LaBat & Sokolowski, 1999; May-Plumlee & Little, 1998; Regan, Kincade, & Sheldon, 1998; Workman, Caldwell, & Kallal, 1999). These models describe current apparel design development and production processes. Regrettably, no apparel design and production model addresses the designers' role in environmental sustainability. Their focuses are functional, aesthetic, and economic (LaBat and Sokolowski, 1999). Nevertheless, product designers should take responsibility in developing and producing products with more environmentally friendly functions and production methods in order to reduce harmful environmental impacts and to improve environmental compatibility (Goan, 1996). Recent studies have shown consumers' environmental concerns are continually growing, and increased green consumerism has put pressure on companies to be more aware of environmental friendly practices (D'Souza, 2004; Kim & Damhorst, 1998; Butler & Francis, 1997). As a result, ecological practices have become more important as marketing strategies for the company.

Despite the growing necessity of environmental practices in the apparel industry, little research has explored methods to guide apparel designers in adapting environmental issues in their work. Many designers do not recognize how their designs impact the environment. One of the reasons for this problem may be that no model or guideline for sustainable development for apparel designers exists.

In addition to the need for developing a guideline for apparel designers, there is a need for understanding consumers' acceptance and preference of environmentally friendly clothing, or EFC, in order to achieve a favorable position in the marketplace.

Economical benefit is one of the key components in sustainable development. Previous green marketing literature stated that consumers who are environmentally conscious will purchase green products and are willing to pay more for them (Fraj & Martinez, 2006; Kim & Damhorst, 1998; Zimmer, Stafford & Stafford, 1994). Another study by Gardyn (2003) also supported this view. He reported the result from a nationally representative poll of 1,000 adults and found that 70% of consumers were more likely to buy products made from companies that had a more environmentally friendly strategy. However, this increased environmentally prudent consumption did not yet extend to apparel purchasing behavior. Consumers' environmental knowledge and conscientiousness influenced other products related to food (because of direct health concerns) and forest consumption, but did not influence apparel products (Kim & Damhorst, 1998; Butler & Francis, 1997). According to Meyer (2001), consumers did not purchase green apparel products because of higher prices, little choice, aesthetic and functional disadvantages, lack of information, and uncertainty about actual benefit to the environment. These studies illustrate the need for an understanding of how to successfully employ sustainable development to the apparel field.

Statement of the Problem

In recent years, sustainable development issues have become more integrated into strategic planning processes in the company (Frankel & Leonard, 2000). With increasing consumer environmental awareness and expectation of the company to accept environmental responsibility, there is a need to expand understanding of how the apparel industry can incorporate sustainable development into their production. Existing apparel design and production models help designers focus on aesthetics, function, and economics but not environmental impacts. Unfortunately, little attention has been paid to apparel designers who hold the key to reducing environmental impacts.

Previous literature suggests that there will be increasing opportunities for green apparel products because of growing consumer environmental concern. Nevertheless, only a few apparel companies have grabbed this trend as a competitive opportunity. Therefore, study of the consumer's preferences and expectations of green apparel products made with sustainable development production strategies is necessary.

Purpose

The purposes of this study are:

1. To develop a new apparel design and production model that allows apparel designers and merchandisers to address environmental issues in their work.
2. To evaluate the newly developed model by
    a. implementing the model to young children's knitwear design and production;
    b. investigating consumers' acceptance of environmentally friendly clothing (EFC).

Objectives

<u>Objective 1: Development of a new apparel design and production model, the Cradle to cradle apparel design and production model (C2CAD), by integrating a sustainable development concept, Cradle to Cradle, into current apparel design and production</u>

models

1. Determine constructs for developing a C2CAD model by reviewing existing apparel design and production models and interviewing apparel designers and merchandisers in the apparel industry.
2. Determine constructs for developing C2CAD model by reviewing existing sustainable development models and interviewing personnel who have achieved sustainable development.
3. Determine constructs and propose model, C2CAD, which integrates sustainable development into existing apparel design and production models

Objective 2: Evaluation of C2CAD model by implementing to young children's clothing production

1. Determine current problems in young children's clothing design and production processes by reviewing literature and interviewing apparel designers and merchandisers in the apparel industry.
2. Develop and produce young children's clothing by using the new model.
3. Evaluate model by case study analysis.

Objective 3: Evaluation of C2CAD model by investigating consumers' acceptance of EFC

1. Develop instruments and select clothing samples for the collection of data regarding consumers' acceptance and preferences for EFC.

2. Investigate consumers' acceptance and preferences for EFC in terms of
    a. product involvement,
    b. price premium,
    c. product performance
    d. environmental concern, and
    e. socio-demographics.

Research Questions

The objectives of this study are addressed in the following research questions.

1. What apparel design and production concepts are considered important to the development of the C2CAD model?
2. What sustainable development concepts are considered important to development of the C2CAD model?
3. How could the C2CAD model be implemented in young children's clothing design and production?
4. Do U.S. consumers who have young children perceive the difference between EFC and non-EFC?
5. Do U.S. consumers who have young children prefer EFC because of a) environmental concern, b) design, and/or c) quality?
6. Do U.S. consumers who have young children not prefer EFC because of a) not realizing environmental benefits, b) price, c) design, and/or d) quality?
7. Does consumers' product involvement influence their acceptance of EFC?
8. Does price premium influence consumers' acceptance of EFC?
9. Does product performance influence consumers' acceptance of EFC?

10. Do consumers' environmental concerns influence consumers' acceptance of EFC?
11. Do consumers' socio-demographics influence consumers' acceptance of EFC?

Working Definitions

In order to clarify specific terminology used within this study, the following working definitions are provided.

Certified Organic: "This means the item has been grown according to strict uniform standards. Certification includes inspections of farm fields and processing facilities, detailed record keeping and periodic testing of soil and water to ensure that growers and handlers are adhering to standards" (Speer, 2005, p.36).

Environmentally Friendly Clothing (EFC): Clothing that is made with environmentally safe materials, such as organically grown cotton and wool, and is made with pollution preventing production methods, such as use of water based inks on prints and safe finishes.

Organic Cotton: Cotton which is grown while "avoiding the use of chemical pesticides, insecticides, fungicides, and defoliants, focusing on building healthy soil and plants through crop rotation and natural fertilizers such as compost and cow manure, and protecting crops through the use if beneficial insects and trap crops" (Speer, 2005, p.36). In the U.S. marketplace, "fibers that are organically grown or raised must be certified organic in-field by an approved third-party certifying organization accredited by the U.S. Department of Agriculture" (Speer, 2005, p.36).

Product Involvement: "Product involvement is related to consumers' level of interest in a particular product" (Solomon & Rabolt, 2004, p.121).

Sustainability: Mihelecic, et al (2003) defined sustainability as "the design of human and industrial systems to ensure that humankind's use of natural resources and cycles do not lead to diminished quality of life due either to losses in future economic opportunities or to adverse impacts on social conditions, human health and the environment"(p.5315).

Sustainable Development: Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987).

Sustainable product: A product that "continues, possibly with design modifications, to meet the needs of its producers, distributors, and customers" (Fiksel, 2003).

Young Children: Children whose age is between 0-4 years; newborns, infants, and toddlers are included in this group (Frings, 2005).

Assumptions

Currently, more and more apparel companies have added environmental friendly clothing to their product assortment. As a result, it is assumed that consumers are likely to have more chances to purchase EFC. Therefore, developing a guideline for apparel designers and investigating consumers' acceptance of EFC will be valuable. Consumers' environmental concerns are reflected by consumption of other products, especially food consumption. Consumers who have young children may be one of the consumer groups most sensitive to risks from environmental problems such as pesticide residues and toxic dyes on cotton fabric based on concern for their children's health and for the future of their children's world. The following are the assumptions for this study.

1) The apparel design and production process in the company chosen for this study is similar to that of the majority of apparel companies in the U.S.
2) The studied parents' acceptance of EFC could be used in representing other consumers' acceptance of EFC.

Limitations

Clothing design and production processes will vary depending on the size of the company, product assortments, and its relationships with supply chains. However, this study will attempt to describe general cases. Apparel products used in the study were limited to young children' knitwear specially made with 100% cotton yarn. In addition, the measuring instrument used will not measure all variables of consumers' environmentally friendly clothing consumption. This study focused on consumers' acceptance of environmental friendly clothing.

This study explored only one segment of US consumers who live in Oklahoma and have young children, to achieve its purposes, and therefore, the results of this study cannot be generalized beyond Oklahoma parents. The need for targeting other regions and other population segments, such as teenagers and adults, is acknowledged for future studies.

CHAPTER II

REVIEW OF LITERATURE

Based on the purpose and objectives of this study, this chapter reviews existing apparel design development and production models and the definition of sustainable development in the product design process to develop a new apparel design and production model, C2CAD. To evaluate the C2CAD model for young children's knitwear design and production, this chapter reviews current problems of apparel production, clothing production for young children, and parents' purchasing behavior. To understand consumers' acceptance and preferences for environmentally friendly clothing (EFC), this chapter reviews consumers' acceptance of environmental friendly products along with evaluations of apparel products.

Apparel Design Development and Production Models

Apparel design development and production models are divided into three categories, product development models, design process models, and production process models. The three categories overlap with each other, and in many studies, there is no distinctive boundary between them because each apparel design process is intrinsically involved with its production process. The design process is the starting point for apparel production; without understanding production, apparel design cannot be realized. In fact, apparel designers often work closely or directly with manufacturers (Frings, 2005). Therefore, this study reviews product development models and design process models together and then reviews production models.

Product development that reflects consumers' needs is a crucial component driving success or failure in a rapidly changing apparel industry (Jang, 2001; Workman, Caldwell, & Kallal, 1999; Gaskill, 1992). Glock and Kunz (1995) stated that product development is the designing and engineering of products to be serviceable, producible, salable, and profitable. Previous literature attempted to compare product development procedures in the apparel industry with other areas such as the engineering field. Kadolph and Langford (2002) affirmed that both apparel and engineering product development require desired serviceability characteristics to the target market and the ability to be made within the ideal time for a profit. Regan, Kincade and Sheldon (1998) employed engineering design process models for a systematic apparel design model. They found a direct relationship between the engineering design process and the apparel design process. Other literature mentioned that textile and apparel product development could be differentiated from other product development because the apparel business is perpetually changed by customer expectations and seasonal rotation (Glock & Kunz ,1995).

Gaskill (1992) developed a retail product development model based on the investigation of specialty retailers carrying private label merchandise. This model (Figure 2.1) has sequential phases from the trend analysis to line presentation, and these sequential processes are influenced by internal and external factors. This model was extended and revised (Figure 2.2) by Wickett, Gaskill, and Damhorst (1999). Wickett, et al. (1999) interviewed retailers who had at least $500,000 of annual sales volume and added additional research of trends and the post-adoption stage. This revised model explains in more detail the internal and external factors that influence apparel product development.

Reagan, Kincade and Seldon (1998) also developed an apparel design process model based on engineering design process models. After they observed ten apparel designers, they concluded that "the apparel design process is a scientific and problematic building block process" (p.40). Therefore, the apparel design process starts with *problem recognition* where designers initiate their ideas for the product development. The next step is *problem definition* and then *exploration of problems*. Unlike previous models with a research step limited to trend analysis, this model emphasized the preliminary steps for creating design. The preliminary steps include *problem statement and solution generation to meet pre-determined needs*.

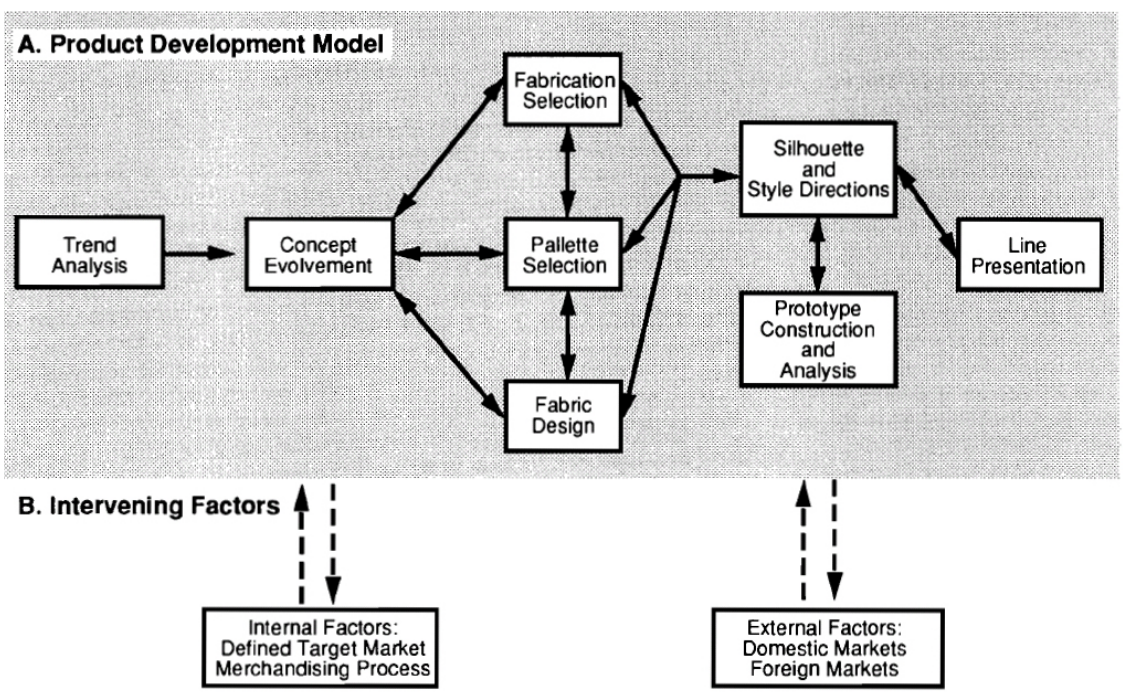

Figure 2.1. The Retail Product Development Model (1992, p.20).

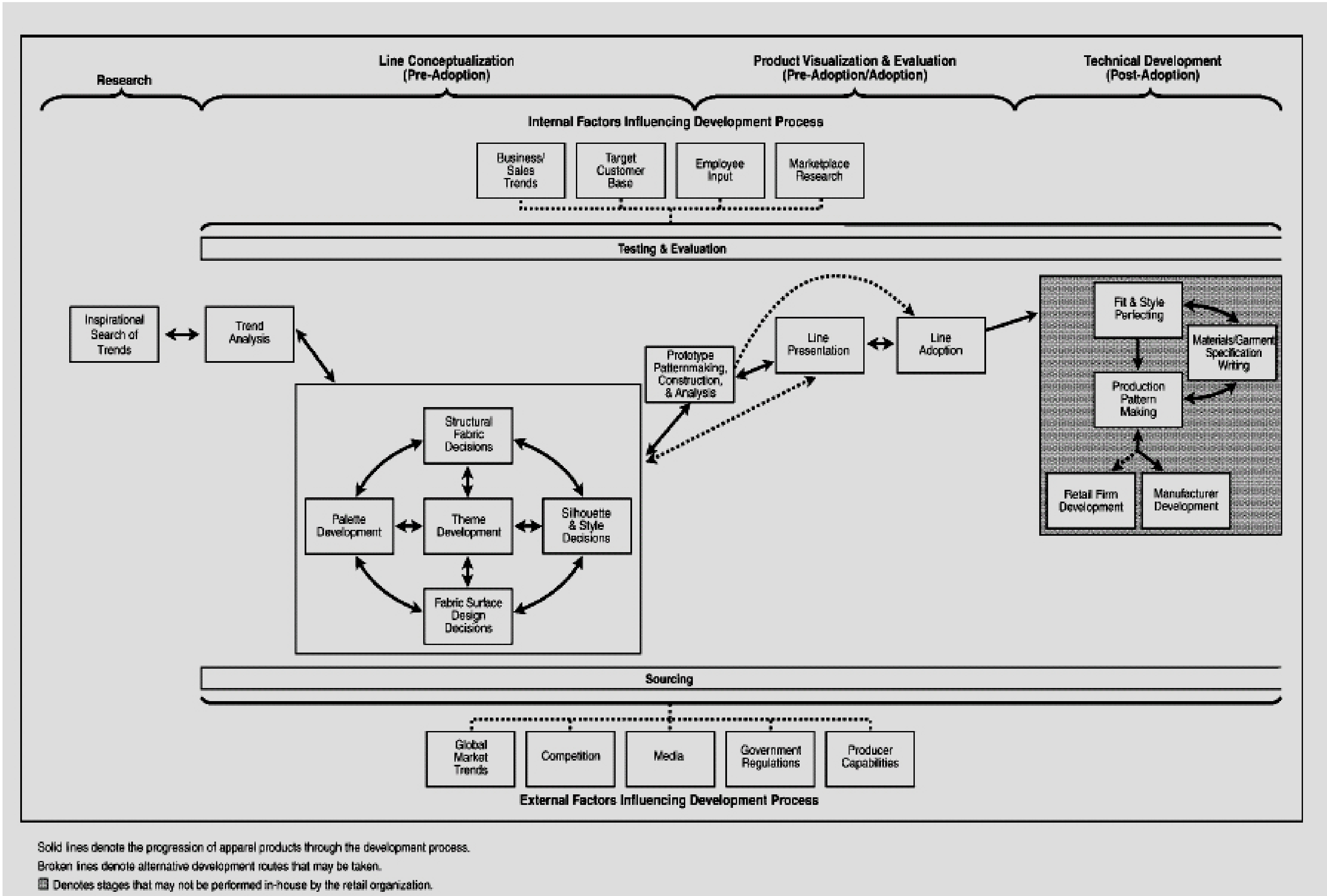

Figure 2.2. Revised Apparel Retail Product Development Model (Wickett et al., 1999)

LaBat and Sokolowski (1999) built a three-stage design process (Table 2.1) for the textile design project. This model was developed based on integration with previous models mentioned earlier. To develop this model, LaBat and Sokolowski (1999) reviewed architecture, engineering, industrial, and previous apparel design models and presented summarized tables of other fields' design processes with apparel design processes (Table2.2). It provides guidelines for how creative thinking evolves into the product design process and suggests approaches for solutions though continual exploration, which is necessary in a sustainable production strategy. LaBat and Sokolowski's model includes components that other models defined, and moreover, it highlights the designer's role in connecting adverse environmental impacts to solutions for these impacts.

Table 2.1. Textile Product Design Process Stages (LaBat & Sokolowski, 1999)

I. Problem Definition & Research	II. Creative Exploration	III. Implementation
A. Initial Problem Definition • Client definition	A. Preliminary Ideas • Expansive, all realm of possibilities	A. Production Refinement • Cost to produce • Time to produce • Methods of production • Sales potential
B. Research • User Needs: -Function -Aesthetic -Economic • Market: -Assess current products -Competitive Analysis -Economic conditions	B. Design Refinement • User constraints: -Function -Aesthetic -Economic • Production Constraints -Cost to produce -Time to produce -Methods of production -Sales potential	B. Phase 1: Immediate Production • Changes in product or production that can be accomplished immediately
C. Working Problem Definition • Defined by industry client & university designer • Design criteria established	C. Prototype(s) Development • Meshing design criteria and constraints to develop workable ideas D. Evaluation of Prototype • Preliminary: by university designer • Final: by university designer and industry client	C. Phase 2: Improvement/Refinement • Further development that may be delayed

Table 2.2 The Summary of Apparel Product Development Process and Engineering Design Process.

LaBat & Sokolowski (1999)		Problem definition and research	Creative Exploration	Implementation
Clothing and Apparel product development process	Watkins (1988)	• Problem acceptance • Variable analysis	• Definition • Idea generation for solution	• Select solution • Implementation
	Lamb & Kallal (1994)	• Problem identification • Preliminary idea	• Design refinement • Prototype development	• Evaluation • Implementation
	Regan et al. (1998) (used Lewis & Samuel's model)	• Problem recognition • Problem definition	• Exploration of problem • Search for alternatives • Evaluation and decisions	• Specification of solution • Communication of solution
Engineering design process	Lewis & Samuel (1989)	• Problem recognition • Problem definition	• Exploration of problem • Search for alternatives • Evaluation and decisions	• Specification of solution • Communication of solution
	Pahl & Beitz(1994)	• Product planning and task clarification	• Conceptual design	• Embodiment • Detail design

(This table is summarized by Pitmaneeyakul, 2001)

To understand the apparel design process, the apparel production process also needs to be considered. May-Plumlee and Little (1998) developed an apparel product development model based on the current U.S. apparel industry. They indicated that previous models contributed to structured understanding but did not provide sufficient details. Therefore, to optimize the model used in the apparel industry, May-Plumlee and Little's model (1998) provided a new model with six phases described in six figures. These six phases were *line planning and research*, *the process of initiating development of specific products*, *the process of translating lines*, *design development and style selection, pre-production, and line optimization.* Another noteworthy aspect of this model was that it included redesigning and production processes, creating a system by which each process can move forward only once the previous process is approved. Therefore, this model included *approved* and *not approved* procedures. It moved in a sequence from line planning and research through production. In every stage of apparel production, designers have to find possible solutions to problems. Apparel design development was described in phase 4 (Figure 2.3). In this phase, after styles were selected based on the market, database, and target consumer research, May-Plumlee and Little (1998) proposed co-development of fabric with vendors, an approach not suggested by other models.

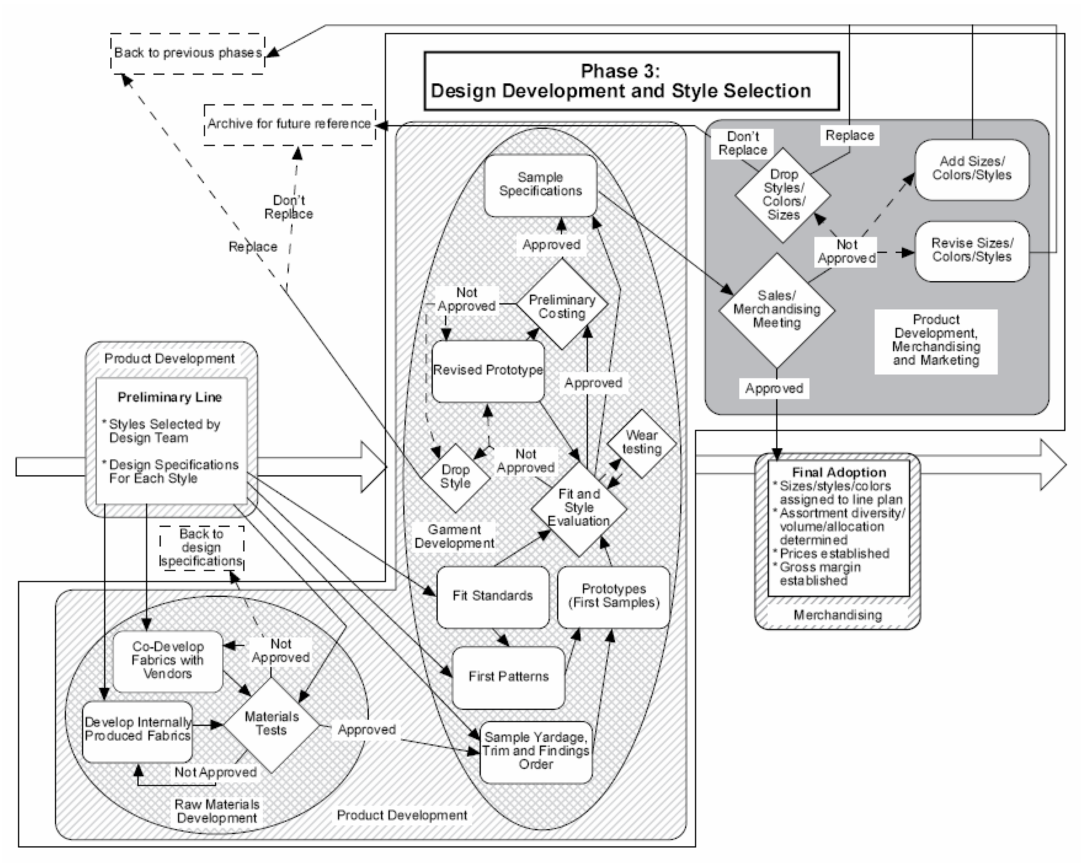

Figure 2.3. Phase 4: Design Development and Style Selection (May-Plumlee & Little, 1998)

The Sustainable Design Model

Sustainability is defined as "the design of human and industrial systems to ensure that humankind's use of natural resources and cycles do not lead to diminished quality of life due either to losses in future economic opportunities or to adverse impacts on social conditions, human health and the environment" (Mihelcic et al., 2003, p.5315). To achieve sustainable development, designers need to be aware of environmental impacts and incorporate environmental awareness into the design (Holdway, Walker, & Hilton, 2002).

Cradle to Cradle Design

McDonough and Braungart (2002) introduced a model of "cradle to cradle" design. "Cradle to cradle" design suggested three key tenets: 1) waste equals food, 2) use current solar income, and 3) celebrate diversity. Current products, which are made with a one-way, cradle to grave, model that does not consider the life of materials after use, only increase waste. The "waste equals food" concept proposed that waste does not need to exist because products can be designed from the onset so that, after their useful lives, they will provide "nourishment" for something new.

McDonough and Braungart defined two material metabolisms: biological metabolism, which is the cycle of nature, and technical metabolism, the recirculation of non biodegradable materials into future products. Materials can be constructed as "biological nutrients" that will easily reenter the water or soil without depositing synthetic materials and toxins, or they can be conceived as "technical nutrients" that will continuously circulate as pure and valuable materials within "closed-loop" industrial cycles, rather than being "recycled" into lower-grade materials (McDonough & Braungart, 2002). The second and third tenets addressed the problem of current human energy systems, which drain natural resources and pollute the environment. The second tenet, "use current solar income," suggested employing natural energy such as solar and wind energy. The third tenet suggested that people can learn from nature's diversity, which maintains its ecosystem indefinitely.

This "cradle to cradle" model provides designers with a new way to design products and eliminate many environmental problems at the very beginning of the product life cycle, during the design phase. The basis of "cradle to cradle" design is the chemical and material assessment protocol (Figure 2.4), which allows designers to assess chemical ingredients against multiple human and environmental health and safety endpoints. Once assessed, the ingredients are flagged using color coding to facilitate decision making. Red indicates an ingredient of potentially high hazard. Yellow is moderate to low inherent hazard, and green indicates that the ingredient is inherently benign for the application. Orange designates ingredients for which necessary data are missing. Cradle-to-cradle design incorporates aspects of green chemistry and green engineering by selecting ingredients and materials that are both inherently benign and capable of behaving as biological and/or technical nutrients within material "metabolisms," thus eliminating the concept of waste (McDonough, et al., 2003).

Braungart (2002) suggested several keys to sustainable design. First, a life-cycle analysis of all materials needs to be considered. Next, selected materials should minimize or eliminate hazardous chemicals. Third, reusable or recyclable materials should be considered when the products are not biological nutrients. In addition, products made with different materials need to be designed to be easily disassembled.

McDonough and Braungart (2001) suggested a five-step strategy to provide a guideline for designers. Designers can start by removing hazardous materials like Polyvinyl Chloride (PVC), lead, or chlorine (McDonough & Braungart, 2001). These materials generate extremely dangerous environmental hazards during production, usage, and disposal**.** After eliminating the harmful materials, personal preference based on scientific knowledge reflects the product development (McDonough & Braungart, 2001). Therefore, designers need to make an effort to obtain knowledge for ecologically intelligent designs. In the third step, designers start to evaluate the materials and product manufacture system and replace problematic materials. The fourth step requires a more progressive evaluation than the third. Designers need to evaluate all aspects from materials selection to production systems to disposal. Finally, designers need to create an innovative method in which a product can be composed of either biological nutrients or technical nutrients for future products (McDonough & Braungart, 2001). This guideline aids designers in gradually transforming current circumstances into sustainable development.

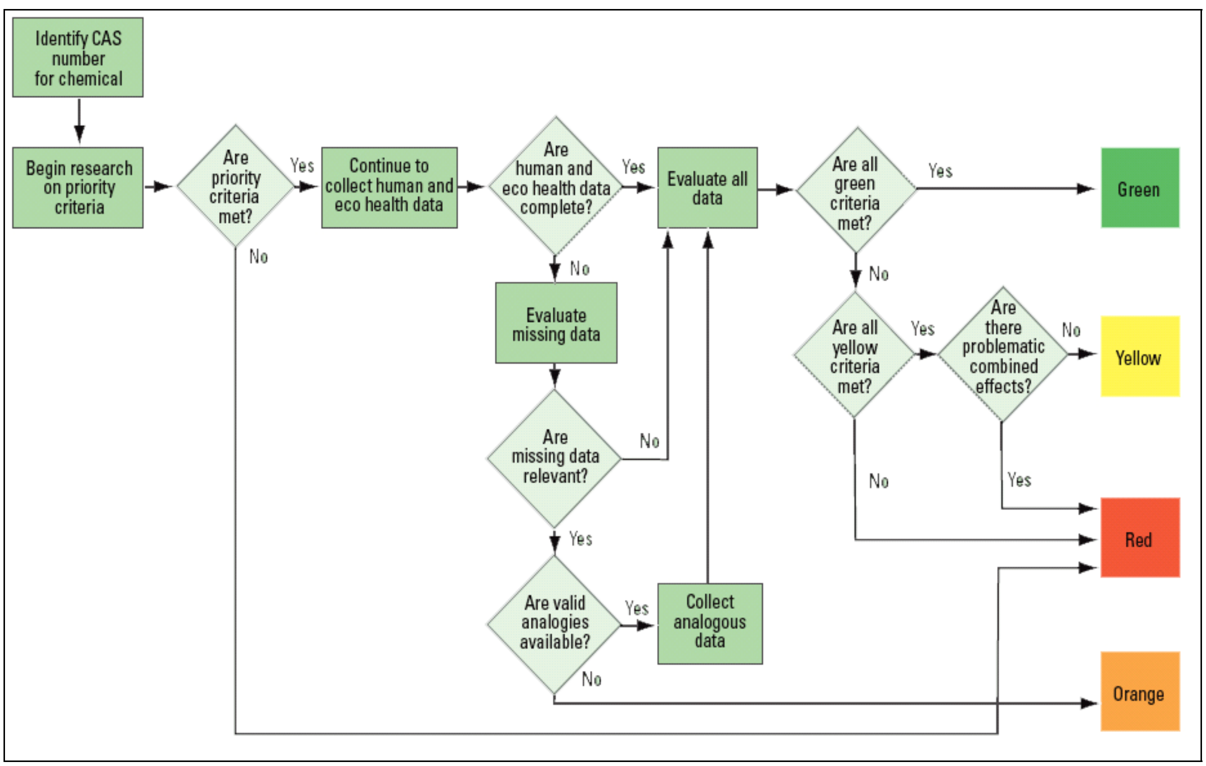

Figure 2.4. Material Assessment Protocol (McDonough, et al., 2003)

The Designer's Role in Mass Production

Designer's ideas for product development should be based on the research of problems and needs**.** The product design reflects the designer's background and information (Prudhomme, et al., 2003). "A designer's lack of knowledge regarding manufacturing processes and manufacturing alternatives can result in nonsalable designs" (Reagan et al., 1998, p.36). For a designer, understanding production processes is essential in mass production.

Sustainable development concepts in product design allow designers to rethink "how we design, what we produce, how we use materials and resources, and what processes we choose to implement in a way that is equally beneficial to the environment and its inhabitants" (Young et al., 2004, p.62). When designers develop products, they should consider the products' usage period; products need to be durable, not immortal (McDonough et al., 2003). In addition, to achieve sustainable production, designers need to understand the environmental impact of every step during the production process, and they need to change their methods if there is a possible negative impact (Pahl & Beitz, 1996).

Though there is not much literature in the apparel field about sustainable production, sustainable development research from the engineering field can be employed in apparel production. Engineering research suggested the problem solving method, created based on the idea that for sustainable development, designers need to analyze every design process and method introduced (Pahl & Beitz, 1996). When designers are confronted with problems, they need to evaluate them by collecting information. Based on the evaluation, the best solution concept can be selected or created.

According to Akermark (2003), “in order to optimize a product from an environmental view, it is necessary not only to know how the product affects the environment but also how to evaluate different solutions and concepts.” (P.2).

Akermark (2003) studied an overview of the designer’s situation in Swedish companies, and he concluded the following:

> In order to integrate the environmental issue in the everyday work of designers it is necessary to have the following conditions: (1) environmental expertise available, (2) an evaluation tool in order to confirm and choose alternatives, (3) education and information for designers to spread knowledge and to motivate them, (4) constant stress on the importance of environmental adaptation, (5) documentation routines and guidelines connected to the product development process to ensure that the issue is considered at every step. (p.3)

Akemark (2003) emphasized the importance of available environmental education, information, and guidelines for designers.

Current Problems in Apparel Production

Environmental Problems in Cotton Production

Cotton is one of the most important fibers in the apparel industry and the fifth largest farm industry, worth an estimated $1 billion annually in seed and lint. in the U.S. (Klonsky et al., 1995). U.S. consumers, more than any others in the world, prefer cotton textile and apparel products. From 1990 to 2003, the consumption of cotton in the U.S. increased from 23.4 to 35 pounds per capita (National Cotton Council of America, 2005)

Regrettably, cotton is one of most heavily chemicals-sprayed crops. A variety of restricted use pesticides containing 21 different toxic ingredients are used on upland U.S. cotton (United States Department of Agriculture: National Agricultural Statistics Service, 2004). One of the pesticides most widely used on cotton fields is Endosulfan, a major cause of river contamination near cotton fields during the pesticide spraying season (Hose et al., 2003). In the U.S., approximately 13 million acres, 97 % of the cotton grown in 12 major cotton producing states, were sprayed with 28 million pounds of herbicides in 1997 (United States Department of Agriculture: National Agricultural Statistics Service, 2004).

Defoliants, chemicals used to remove only the leaves of a plant, are a particularly harmful class of toxins. Defoliants are used by cotton farmers because they increase efficiency by "reducing foliage as well as decreasing seed moisture, boll rotting, and pink bollworm and boll weevil populations" (Ball, 1999, p.1). Unfortunately, people who have lived or worked near a defoliant-applied cotton growing agricultural community have shown 60-100% higher rates of fatigue, irritation, rhinitis, throat irritation, nausea, and diarrhea than people in non-cotton growing agricultural communities (Scarborough et al., 1989). If there are accidents or major spills, respiratory paralysis and death can occur (U.S. Environmental Protection Agency, 2000).

Between 150 to 330 pounds per acre of soil-depleting nitrogen fertilizer was applied to conventional cotton farms in the US. This amount translates to 1/3 pound of agricultural chemicals for each cotton T-shirt produced (Kamila, 2003)

Environmental Problems in the Textile and Apparel Industry and Disposal

To improve cotton fabric performance properties, the apparel industry commonly performs wet processing such as desizing, scouring, bleaching, and mercerizing. This wet processing generates a significant amount of wastewater and "there is still uncertainty about the toxicity of most chemicals used" (Ren, 2000, p. 474).

Dyeing processes can generate environmental problems through the discharging of dyes, pigments, and other chemicals into the water. According to Kadolph and Langford (2002), color, salt, acids, and heavy metals in dyes cause environmental problems because of high biological oxygen demand (BOD) and high chemical oxygen demand (COD). "High BOD and COD materials create environments that are hostile to aquatic plants and animals and may create problems with future use of the water" (p.337). In addition, salts are not eliminated in conventional wastewater treatment processes (Hessel et al., 2007). Wastewater from various textile treatment processes contains varieties of aquatic toxicity such as toxic organic chemicals, biocides, phenols, phosphates, metals, toxic anions, and polybrominated diphenyl ethers (PBDEs) (U.S. Environmental Protection Agency, 2000; Hendrickx, 1995). In southern Virginia, high levels of PBDEs, used for flame retardant processes, were found in fish. This toxicity can build up in people as well, and the concentration of PBDEs found in mothers' milk has been increasing radically in recent years (Environmental News, 2000). Although there has been no research on human health problems resulting from PBDEs, laboratory animal testing found that PBDEs interfere with brain development during the prenatal period (Duff, 2006).

Currently, the apparel industry commonly uses plastic inks made from polyvinyl chloride (PVC) plastic because they are low cost and versatile (Kamila, 2003). However, PVC is now recognized as one of the most environmentally hazardous materials ever produced because it contains dioxin and phthalates. In addition, according to Peralta-Zamora et al. (1999), reactive dyes cause more serious environmental problems than other dyes because they are more resistant to biodegradation, and contain toxic or carcinogenic compounds. Regrettably, reactive dyes are used to dye more than half the global production of cotton (Hessel et al., 2007).

In addition to water pollution, air pollution is also an environmental hazard of conventional textile production. There are two sources of air pollutant emissions in the cotton textile sector. The first is combustion flues, which emit chemical gases and vapors of toxic or hazardous chemical gases, and the other is dust and lint emissions and various solvents or evaporated chemical additives during production processes (Müzzinoğlu, 1998). If fabric is made with hazardous materials, "the presence of suspended particulates in the air in cotton textile production workplaces puts forward a serious challenge for the health of the workers" (Müzzinoğlu, 1998, p.342).

Cutting and sewing waste just from cotton knit apparel production is almost 176 million pounds per year (Harris, 1996). Since this waste contains dyes, and other chemical residues, it can be hazardous because waste buried in a landfill can contaminate groundwater and generate gas and odor (Hendrickx, 1995). If manufacturers do not use appropriate waste management systems, these wastes can damage the environment and human health. Annually, 4.5 million tons of clothing and footwear are produced in the U.S., and only 1.25 million tons of post-consumer textiles are recovered for reuse (U.S. Environmental Protection Agency, 1996). The rest goes to the landfill.

Organic Cotton Production and Organic Cotton

Although organic cotton farmers took the initiative to produce the world's first certified organic cotton in the late 1980s, the demand for organic products has recently increased, and organic farming is a quickly growing segment of U.S agriculture (Ton, 1995). *Certified organic cotton* must be grown and processed in accordance with applicable national and state laws. A trained certifier from a third party inspects organic farming to ensure organic farms meet state and federal guidelines (Bunin, 2001). In the U.S., California Certified Organic Farmers (CCOF), the Texas Department of Agriculture, the Organic Crop Improvement Association (OCIA), and Quality Assurance International (QAI) certify the majority of organic cotton grown (Bunin, 2001).

Defoliation is a significant challenge for organic cotton production (Guerena & Sullivan, 2003). Several alternatives for chemical defoliation methods are suggested for organic production, but alternative methods generally require human labor (Guerena & Sullivan, 2003). One alternative to chemical defoliation is a heat treatment method that uses heat at 250-350˚F (121-177˚C). This alternative defoliant method allows two weeks faster reaping than chemical defoliants, but requires more human labor than chemical treatments, which in turn increases production cost (Funk, 2003).

Swezey and Goldman (1996) analyzed the cost of both organic and non organic cotton production and found that organic cotton costs approximately 50% more to produce than non organic cotton. Most of the cost difference was generated from fertilizer materials and mechanical weed control. In addition, if companies want to produce a small volume of organic cotton products, they have to pay more per product for manufacturing. The total cost for small volume production before marketing increases between 20-40% (Nimon, 1999). Although organic cotton production has more environmental advantages than non organic cotton production, Nimon (1999) found that using organic cotton did not attract consumers because higher standards for environmental friendly products causes higher prices. Even consumers who were more concerned with their health were not motivated to buy organic apparel (Nimon, 1999). However, another study found that organic clothing can often be sold at a higher price than conventional clothing (Klonsky, et al., 1995).

Currently available organic cotton clothing is more expensive, and consumers' acceptance of organic cotton clothing is poor because of higher price, little choice, and limited availability (McConnell, 1998). There are several reasons for the higher costs of organic cotton. Organic cotton crops are grown with rotating programs (McConnell, 1998; Speer, 2005). Every three years, land must be out of production because organic cotton does not use synthetic fertilizers. Additional costs are incurred for the certification process (Speer, 2005). Alternatively, because organic cotton production does not use synthetic pesticides, insecticides, or fertilizers, the high cost of these synthetic chemicals can be eliminated. In the long term, this may reduce production costs (Speer, 2005).

Children's Clothing Purchasing Behaviors

Children's clothing sizing is defined by age groups (Table 2.3). The actual purchasers for infants, toddlers, and young children are parents, grandparents, or other adults; therefore, parents' opinions are definitely reflected in children's clothing sales (Frings, 2005).

Table 2.3. The Sizing Systems for Children's Wear (Frings, 2005)

Newborn	Sizes are layette (0-11 pounds), 3, 6, and 9 months.
Infant	Sizes are based on age in months, usually 12, 18, and 24 months, In Europe, sized are based on the length of the baby or the height of the child.
Toddler	Apparel for the child who has learned to walk, are sized 2T, 3T, 4T. At this point, sizes separate for boys and girls.
Girls	Girl's apparel is sized 4 to 6X, 7 to 16 (Some companies manufacture size 2 to 10 or extra-small to extra-large), preteen sizes are 6 to 14, and young teens wear junior sizes 3 to 13.
Boys	Sizes are 4 to 7 and 8 to 20.

Relatively earlier literature found that price is more important than any other factors, such as quality and design, in determining what parents will purchase (Darian, 1998). One reason could be that children grow quickly and parents need to replace their clothing often. However, recent literature mentioned that price is not a critical factor for parents' purchase of children's clothing (Chen et al., 2004; Kőksal, 2007). In addition, recent trends for small children's clothing have changed. Sales on infant and toddler apparel have increased over the last five years while the birth rate has decreased (Verdon, 2003). One of the reasons for this trend could be that there are fewer numbers of children in families, so their parents and grandparents spend more money on gifts (Verdon, 2003). Another reason could be that many of today's parents have their first child when they are in their mid-30's, after achieving stable careers and earning more disposable income (Prendergast & Wong, 2003). To adapt to this trend, companies for young children's clothing have diversified into two segments (Verdon, 2003). One segment sells moderately-priced clothing, and the other sells luxury or high-priced items. Parents' interest in brand name and luxury apparel is increasing, and luxury brand companies are extending their product lines into the young children's market (Corral, 1999).

Due to increased anxiety about health effects from pesticide residues and unsafe dyes on cotton fabrics, parents with young children have shown an interest in organic cotton (Nimon & Beghin, 1999) because children are more vulnerable to the potential toxins, such as pesticide residues and unsafe dyes used in apparel. A recent survey by Wal-Mart found that 74% of parents who have young children are interested in organic apparel (Nolan, 2006). Another viable reason for parents' interest in organic clothing is that they want to preserve the future environment for their children. This reason is supported by the survey results of Butler and Francis (1997). They found that consumers who have children showed higher environmental concern.

Prendergast and Wong (2003) attempted to identify the behavior of parents who purchase luxury brands of infant clothing in Hong Kong. Parents said their reason for purchasing luxury brand clothing for their young children was that luxury brand clothing has better quality and design. Only a small number of respondents said they purchased luxury brands for conspicuous consumption. This result could be applied to the acceptance of EFC for young children if environmentally friendly characteristics are perceived as synonymous with high quality to parents.

Research has shown that a complex combination of factors affects consumer clothing purchasing decisions. Product quality, design, and style were important in clothing evaluation. In addition, one of the reports showed that people preferred organic cotton clothing because it maintained a better tactile sensation, which was important for young children. This factor also explained why consumers who did not have environmental concerns bought EFC.

Consumers' Acceptance of Environmentally Friendly Clothing (EFC)

Specific points considered when approaching this study of consumer acceptance of apparel being design and production using environmentally sustainable materials included factors identified in Fishbein and Ajzen's theory of reasoned action (1975). According to them, a person's beliefs are developed by "direct observation and information received from outside sources" (p.14). These beliefs also influence a person's attitudes, or positive or negative evaluation of an object. Furthermore, behaviors and attitudes are relevant to intention to perform behavior. This study examined attitudes as a factor influencing individual behavior. In addition, other factors such as involvement in children's clothing and children clothing purchasing behaviors were examined to understand costumers' acceptance of EFC.

The Influential Factors of Consumers' Environmentally Friendly Products (RFC) Purchasing Decisions

Environmental Concerns and Socio-demographic Information

Increasing concerns about food safety have caused the dramatic growth of the organic food industry in recent years. In 2002, the consumption of natural and organic food in the US equaled $13.5 billion, 8.9% higher than in 2001(Murphy, 2004), and as of 2005, the annual rate of growth of the organic market was about 20% (Berry, 2005). Previous literature has found that consumers who have more environmental concerns purchase more green products (Lannuzzi & Haviland, 2006; Diamantopoulos, et al., 2003; Zimmer et al., 1994). Recent research has also suggested that today's consumers are more conscious of negative health and environmental impacts from pollution because there is currently more information available about environmental problems (Murphy, 2004).

Some literature indicates that demographic and socio-demographic information can be used to estimate environmental concern. Diamantopoulos, et al., (2003) employed gender, marital status, age, income, family size, education, and social class as indicators. Similarly, Butler and Francis (1997) also employed socio-demographic information to define the ecologically-concerned consumer and found that consumers who favor environmental regulations, those who are older, and/or who have families, considered the environmental impact of clothing production and showed higher interest in clothing conservation. They conducted a path analysis to observe the influential relationship among general environmental attitudes, clothing and environmental attitudes, and clothing purchase behavior. Their results showed that clothing conservationist factors influenced environmental purchasing behavior. Consumers who cared about drained resources and environmental impacts from clothing production showed higher environmental purchasing behavior.

While Butler and Francis (1997) did not find a direct relationship between higher education levels and increased environmental purchasing, they did find that less educated consumers cared less about environmental impacts from clothing production. Therefore, because education level helped determine environmental concern, it had an indirect effect on environmental purchasing behavior. A study by Bohlen et al, (1993) showed that better educated consumers had greater environmental concerns. Ling-Yee (1997) investigated the ecological attitudes of Hong Kong consumers and found that "people who are male, those who earn higher income, and people who have high involvement in the health food category, engage in more extensive green product-related information search and purchase green products more frequently" (p.50). In another study, Bjørner, Hansen, and Russell (2004) explored whether environmental labels affect purchasing decisions for toilet paper. They discovered that environmental labeling had a significant effect based on consumers' gender and the presence of their children in the household but not on their income or education. Consumers who were female and had children were more likely to purchase environmentally labeled products.

Researchers' other approach for determining environmental concern involved employing environmental attitudes, knowledge, and behavior to measure environmental concerns. Bohlen, et al. (1993) developed three indicators—knowledge about environmental issues, attitudes about the environment, and environmentally sensitive behavior—to measure ecological concerns in accordance with previous literature. They also divided environmentally sensitive behavior into two parts: 1) non-purchasing environmental behavior, for example, recycling, and 2) purchasing behavior.

According to Fishbein and Ajzen (1975), a person's attitudes, which influence behavior, are built by learning from factors such as past experiences, concerns, information, and social pressure. Therefore, understanding consumers' environmental concerns and socio-demographic information is essential to understanding both attitudes toward EFC and purchasing decisions.

Price Premium

Consumers' attitudes toward organic cotton products vary depending on the increased price of the organic products. Most consumers, 81% of Bhate and Lawler's

(1997) respondents, said that EFPs are expensive, but they frequently or sometimes purchased these products. Furthermore, some consumers perceived price premium as a guarantee of quality and safety (Jones et al., 2001).

Anderson et al. (2005) conducted an experiment on university students' purchasing behavior on eco-labeled and normal pencils. Both pencils had the same color and design. When the two types of pencils had the same price, more eco-labeled pencils sold. When the eco-labeled pencils were priced 20% more, the number of the two types of pencils sold was statistically similar. When the eco-labeled pencils were priced double, the number sold decreased but still equaled 30% of total sales. The price evidently influenced pencil purchasing, but some consumers were willing to pay more for environmentally friendly products. In addition, a post-purchase survey found that not only price influenced purchasing decisions, but also influencing purchase decisions was the fact that consumers did not see any actual environmental benefits from purchasing eco-labeled pencils. D'Souza (2004) divided consumers into four groups depending on cognitive perspectives and recognition of benefits or risks: *environmentally green consumers, emerging green consumers, price sensitive green consumers, and conventional consumers*.

Laroche et al. (2001) investigated the demographic, psychological, and behavioral profiles of consumers to identify which consumer types were willing to pay more for environmental-friendly products. They found that married females with at least one child were the most willing to pay more for environmental products. This result indicated that having children can motivate parents to behave ecologically because parents are aware of environmental impacts on their children's future. However, Laroche et al. (2001) did not identify how much more consumers will pay. Nimon and Beghin (1999) collected data from apparel catalogue retailers and found that consumers were willing to pay more, about 33.8%, for organic cotton products. In addition, consumers were willing to pay between 13% and 18% more for environmentally-friendly toilet paper (Bjørner, et al., 2004). The information on consumers' reaction to price will be useful for apparel companies to produce EFC within competitive price ranges.

Consumer Involvement with Products

"Consumer involvement is defined as the perceived importance or interest attached to the acquisition, consumption, and disposition of good, service, or idea;" therefore, "different consumers may react with divergent levels of involvement to various products" (Mowen & Minor, 2001, p.39). Attitudes toward environmentally friendly products change depending on the level of consumer involvement in products. If health is the highest priority for consumers, they purchase organic foods for its nutritional value rather than for environmental reasons. However, if consumers regard environmental or ethical aspects as very important, they buy the environmentally-friendly detergent even at a higher price. Fotopoulos and Krystallis (2002) surveyed Greek consumers about organic food. The overall reasons Greek consumers purchased organic food were that it was environmentally friendly, healthy, tastier, and of better quality.

Although many kinds of environmentally-friendly products are available, not all products obtain consumers' favor. Environmental messages, advertising, and labels can increase consumer involvement. Several studies were conducted to determine environmental labeling effectiveness (Table 2.4). These results showed that consumer involvement changes depending on a product's category and information on the environmental label. In addition, accessibility and convenience also influence consumer involvement with products (Solomon & Rabolt, 2004; Bhate & Lawler, 1997) as consumers can only buy products that are available.

Consumers have different depths of involvement with particular products, and these depths influence their behavior. Product involvement affects the relative importance of the product class and the perceived difference in product attributes (Solomon & Rabolt, 2004). Consumers, who purchase organic food or recycled paper, may not purchase environmentally friendly clothing (EFC) because "Apparel and fashion purchasing is generally thought of as a high-involvement activity" (Solomon & Rabolt, 2004, p.122). For this study, product involvement, such as *shopping for children's clothing* and *purchasing of organic cotton clothing,* was measured by Zaichowsky's personal involvement inventory (1994): Important/unimportant, boring/interesting, relevant/irrelevant, exciting/unexciting, means nothing/means a lot to me, appealing/unappealing, fascinating/mundane, worthless/valuable, not needed/ needed. Understanding parents' involvement in both children's clothing and EFC is very important to the apparel company producing or planning to produce children's EFC. For this study, involvement related to children's clothing was determined in order to observe whether this involvement is related to consumer selection of EFC. Also, consumer involvement in organic cotton clothing was used for measuring consumers' acceptance of EFC (DV).

Table 2.4. The Effect of Environmental Labels and Product Characteristics

Product	Environmental characteristic	Did label have an effect?
Detergent	Content of phosphate	Yes
Canned seafood and substitute meat products	Dolphin-safe label	Yes
Toilet paper	Unbleached	No
	Recycled	Yes
Apparels	Environmentally friendly dyes	No
	Organic cotton	Yes
Electricity	Certified green electricity	Yes

(This table is adapted from Bjørner, Hansen, & Russell, 2004)

Research Conceptual Framework

The proposed conceptual framework (Figure 2.5) was developed based on the previous studies mentioned earlier with the addition of topics to be researched in this study. Five independent variables were identified that influence the acceptance of EFC: 1) socio-demographics, 2) product involvement, 3) price premium, 4) product performance, and 5) environmental aspects. The dependent variable was the acceptance of EFC. This acceptance was measured by three factors: 1) selection of children's organic cotton clothing, 2) willingness to purchase EFC, and 3) product involvement with organic cotton. The goal of measuring willingness to purchase EFC was to understand consumers' general opinions about EFC. Participants were asked about their willingness to purchase EFC and to pay more for EFC. Consumers may show an interest in EFC, but their actual selection may be different. Therefore, a real selection between organic cotton and non organic cotton clothing was presented to participants. Currently, most available EFC is organic cotton clothing. Measuring involvement with organic cotton allowed this study to see whether participants were interested in purchasing organic cotton clothing. To measure involvement, this study employed Zaichowsky's personal involvement inventory.

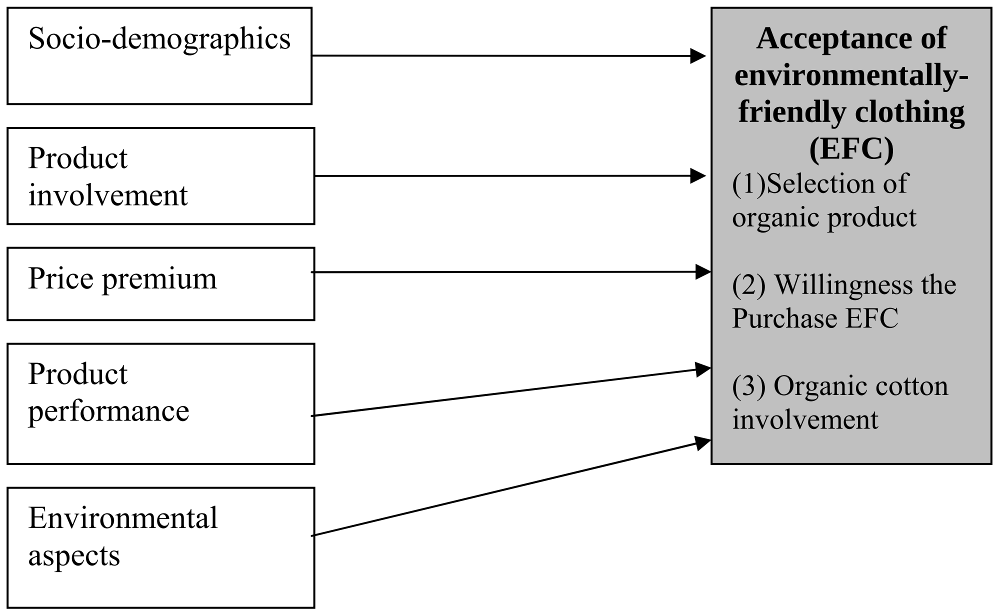

Figure 2.5. Conceptual Framework

Hypotheses

Based on the review of literature, hypotheses were formed. Null hypotheses were categorized by independent variables.

Socio-demographics

Socio-demographics were used to determine the relationship of 1) selection of organic cotton and 2) involvement with organic cotton. Participants' age, education level, employment status, and income level were included in socio-demographic variables.

$H1_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of socio-demographics.

H1-1$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their age.

H1-2$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their education level.

H1-3$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their employment status.

H1-4$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their income level.

H2$_0$: There are no significant differences in "involvement with organic cotton" among different levels of "socio-demographic information."

H2-1$_0$: There are no significant differences in "involvement with organic cotton" among different levels of age.

H2-2$_0$: There are no significant differences in "involvement with organic cotton" among different levels of education.

H2-3$_0$: There are no significant differences in "involvement with organic cotton" among different levels of employment status.

H2-4$_0$: There are no significant differences in "involvement with organic cotton" among different levels of income.

Product Involvement

This study included: 1) items from Zaichowsky's personal involvement inventory, 2) the frequency of shopping for children's clothing, and 3) money expenditure on children's clothing as a measure of product involvement because participants who have a higher interest in children's clothing, meaning they spend more time and/or more money on it, may show a higher interest in organic cotton. This study utilized Zaichowsky's personal involvement inventory twice. The first instance was in measuring involvement with children's clothing (2nd independent variable), and the second was in measuring involvement with organic cotton (3rd dependent variable).

$H3_0$: There is no relationship between the personal involvement inventory with children's clothing and the personal involvement inventory with organic cotton.

$H4_0$: There are no significant differences in "willingness to purchase EFC" between different levels of "frequency of shopping for children's clothing."

$H5_0$: There are no significant differences in "willingness to purchase EFC" between different levels of "money expenditure on children's clothing."

Price premium

The price premium factor was measured to see whether or not pricing information influenced the selection of EFC. In addition, participants were asked their reason for selecting organic cotton clothing because price may be a deciding factor when selecting children's clothing.

$H6_0$: There is no relationship between different price information and "selection of EFC."

Product performance

This study defined design, quality, fabric, and softness as product performance.

The relationship between product performance and selection of organic cotton clothing was formulated as hypothesis 7.

$H7_0$: There is no relationship between product performance and selection of organic cotton clothing.

Environmental variables

Environmental variables included environmental concerns, environmental attitudes, environmental knowledge, recycling behaviors, and environmental purchasing behaviors. Environmental variables were compared to involvement with organic cotton, which was measured by Zaichowsky's personal involvement inventory.

$H8_0$: There is no relationship between environmental variables and the involvement with the organic cotton.

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CHAPTER III

METHODOLOGY

The purpose of this study is to develop a new apparel design and production model that allows apparel designers and merchandisers to address environmental issues in their work and to evaluate the newly developed model by 1) applying the model to young children's clothing design and production and 2) investigating consumers' acceptance of environmentally friendly apparel products. The first objective is the development of a new apparel design and production model (C2CAD). The second objective is evaluation of the C2CAD model by implementing it to design and produce young children's clothing. The third objective is evaluation of the C2CAD model by investigating consumers' acceptance of environmentally friendly clothing (EFC). The purpose of this chapter is to describe the methods to be used in conducting this study. This chapter consists of two parts. The first part describes qualitative research approaches for objectives 1 and 2. The second part, the quantitative analysis, will be used for objective 3.

Qualitative Research Approach

Qualitative research "often comes from real-world observations, dilemmas, and questions and emerges from the interplay of the researcher's direct experience, tacit theories, and growing scholarly interest" (Marshall & Rossman, 1995). A qualitative research approach is appropriate when new programs, events, knowledge, and phenomena appears, and there is not enough relevant research and no standardized instruments have been developed to measure the emerging problems (Patton, 2002). Researchers can acquire in depth and richly detailed information about a small number of cases through the qualitative researching approach from description, observation, and categorization. Due to the lack of an apparel design and production model which considers the designer's role in reducing environmental impacts, this study will employ qualitative research to explore ways to implement sustainable development in the apparel design and production process. Qualitative research will allow this study to create preliminary suggestions for the apparel industry to use in practicing or improving an environmental strategy.

Methods of Data Collection

There are several methods for collecting data for qualitative research. This study used analyzation of written documents to define the apparel design model and to recognize problems. According to Marshall & Rossman (1995), like quantitative research, qualitative research should be guided by systematic considerations from the literature review in generating research questions. From the literature review, researchers can identify the gaps between previous literature and that which this study will contribute.

This study involved in-depth interviews with five apparel industry personnel (three designers, one manager, and one owner) in two apparel companies in South Korea. Site selection criteria for this study were (1) these companies both have design and manufacture facilities; (2) they had a long company history in the apparel industry; (3) they showed a willingness to participate in this study. Company A has produced mainly knitwear products, and their target market is middle-aged women and young men. Company B has produced mainly jersey and woven products including denim products, and their target market is casual wear for adolescents. Company A has 31 employees including four designers and three managers. Company B has twelve years of history producing jeans and woven products, and has 36 employees including nine designers and two managers. Three designers, one manager, and one owner from each of the two companies participated in the interviews. The interviews were conducted with an interview guideline (Appendix B). A voice recorder was used to increase the reliability of data collection and analysis.

The methods included the use of case study as an evaluation tool. When a researcher conducts an in-depth study of the cases under consideration, the case study approach is beneficial (Hamel et al., 1993). In addition, case study "is appropriate when investigators desire to (a) define topics broadly, not narrowly, (b) cover contextual conditions and not just the phenomena of study, and (c) rely on multiple and not singular sources of evidence" (Yin, 1993, p.xi). Multiple sources of evidence will minimize the weakness of the single case study approach (Patton, 2002). Case studies can be achieved by various methods such as interviews, participant observation, and field studies. In addition, case study will aid the researcher in finding potential problems in a situation "because the explanatory case study has focused on process not just outcome variables" (Yin, 1993, p.71). In conducting and reporting the case study, "the data collection process should culminate in the creation of a formal, case study database – whether including organized field notes, archival documents and records in the retrievable form, tabular materials, or even the investigator's own narrative responses to the case study protocol" (Yin, 1993, p.71).

Research Procedure

Propose Cradle to Cradle Apparel Development (C2CAD) model

To develop a new apparel design and production model which will allow apparel designers and manufacturers to consider environmental sustainability in their design and production processes, this study examines previous literature of apparel design and production models and sustainable design model, Cradle to Cradle. Apparel industry personnel were also asked about apparel design and production processes. Consequently, this study found common information to answer research questions 1 and 2:

1. What apparel design and production concepts are considered important to the development of the C2CAD model?
2. What sustainable development concepts are considered important to development of the C2CAD model?

After reviewing the previous literature mentioned in chapter 2 and content analysis from interview results, this study proposes a preliminary C2CAD Model (Figure 3.1). The C2CAD has four main stages: 1) problem definition and research, 2) material selection, 3) solution development and collaboration, and 4) production. In Stage 1 of the C2CAD model, problem definition and research, designers define problems and analyze market and company situations. Designers need to understand the users' functional, aesthetical, and economical needs. Conducting research to satisfy these needs and generating design ideas are necessary steps in this stage. At the end of this stage, apparel styles should be decided upon. After selecting styles, in Stage 2 - material selection, designers assess chemical ingredients based on the "cradle to cradle" chemical assessment protocol and materials based on their feasibility as biological or technical nutrients.

Stage 3 of C2CAD is solution development and collaboration. In the current industrial division, most apparel manufacturers do not produce textile fabrics, dyes, and other apparel materials. Co-development of fabric with vendors is a component in May-Plumlee and Little's apparel production model (May-Plumlee & Little, 1998). In the "cradle to cradle" model, Braungart (2002) proposed "intelligent materials pooling" that emphasizes collaborative approaches such as shared knowledge and resources as an important strategy in sustainable development. In the C2CAD framework, apparel designers and manufacturers will collaborate with other companies in the supply chain to solve material problems, such pollution or waste, by switching to environmentally friendly materials.

The last stage, Stage 4 in the C2CAD model, is production. In addition to safety of material inputs and sustainable material flows, considerations regarding sustainability include energy use, air emissions, water use, and solid waste. Collaborations with other industries, such as companies that produce renewable energy or companies that uses solid waste from apparel production as their biological nutrients, may be needed to reduce or eliminate harmful impacts during production.

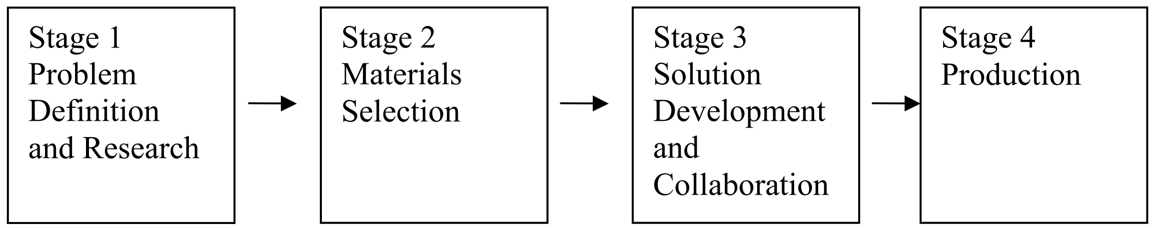

Figure 3.1 Preliminary C2CAD Model

Implement C2CAD model in Knitwear Design and Production

Knitwear design and production was used to evaluate the C2CAD model for this study. One significant reason for selecting knitwear is that almost all processes are observable, from the yarn to the final product. Additionally, the knitwear industry is one of most important components of the apparel industry as a whole, and like other apparel products, knitwear production generates environmental problems throughout its life cycle from raw materials through production to usage and disposal. One manufacturer in Korea which has a design development division and a production line has been selected to cooperate in developing children's knitwear for the study. This study has attempted to follow the design and production processes as proposed in the C2CAD model to produce young children's knitwear.

For the first stage, problem definition and research, this study identified consumers' needs for function and design. After creating the design, stage 2 – material selection, will begin. Materials used in knitwear include textile fiber material and chemicals. Material selection is closely related to stage 3, solution development and collaboration. When designers do not have information about the environmental impact of materials, they may go back and forth between stages 2 and 3 several times. The last stage in C2CAD is production. The production process in knitwear includes dyeing, knitting, and assembling. a yarn dyeing method was used rather than fabric piece dying in this project since the knitwear industry uses more yarn dyeing, especially for complicated pattern designs (jacquard or intarsia). The C2CAD knitwear products have a jacquard and intarsia pattern design, so several dyes to dye yarns for different colors were used. This study used flatbed knitting rather than circular for two reasons. First, flatbed knitting will allow testing of fabric properties such as color fastness easier than circular knitting. Second, a flatbed knitting machine is easier to operate, which is more practical for our pilot study. Final production was completed in a real production line after sending dyed yarn with design descriptions.

Evaluate the C2CAD Model

To evaluate model, this study employed a case study method. According to Yin (1993), the case study method can be used as an evaluation tool. For example, case study has been applied in the use of demonstrations in federal initiatives in the U.S. as either policy-implementing or policy-formulating. In addition, the case study method is beneficial when the researcher needs a holistic understanding of a single case (Patton, 2002). Therefore, content analysis and description of the entire process of knitwear design and production were realized. Especially, this description helped to find possible sources of information for answering research question 3:

3. How could the C2CAD model be implemented in young children's clothing design and production?

In addition, the knitwear produced from the C2CAD model and that of traditional manufacturing was compared for performance and cost. The manufacturer who cooperates in producing the knitwear provided us information about traditional manufacturing designs and production processes including total production cost. Both the C2CAD knitwear and traditionally manufactured knitwear was tested for laundry color fastness, dimensional stability, and abrasion resistance. The knit fabrics' colorfastness and dimensional stability to laundering was tested in accordance with the American Association for Textile Chemists and Colorists (AATCC) standard test methods 61-2003 and 135-2003. Abrasion resistance of the knit fabric was measured in accordance with ASTM D3884. A t-test was used to statistically analyze the data to determine whether there is a significant difference between these two knitwear products in both performance and cost.

Revision of the C2CAD Model after Evaluation

In accordance with the findings from production and evaluation of the C2CAD knitwear, the C2CAD model was revised as needed.

Quantitative Research Approach

The success or failure of products is determined by whether or not products attain consumers' acceptance. Therefore, understanding consumers' acceptance of products is necessary for a company to become competitive.

Questionnaire Development

In order to collect the information of consumers' acceptance on environmentally-friendly clothing, this study chose a survey method and follow-up discussion. This study developed an instrument suitable for quantitative analysis based on a comprehensive review. Self-administrated questionnaires were distributed with the clothing sample. The questionnaire consisted of five parts. First, socio-demographic information was obtained to determine respondents' profiles and to examine socio-demographics in relation to the selection of organic cotton clothing and the involvement with organic cotton. Respondents' age, education level, employment status, and income level were obtained.

The second section of the questionnaire was related to participants' involvement with children's clothing. Respondents' clothing purchasing behavior for their children was included as items measuring product involvement. The questionnaire inquired frequency of shopping, money expenditure to children's clothing, brand or store preference, and other important evaluation criteria. In addition, product involvement with children's clothing and organic cotton clothing was measured by Zaichowsky's (1994) personal involvement inventory. (Table 3.1)

The third part of the questionnaire was the buying scenario, which examined the influence of increased pricing on selection of organic cotton clothing. Respondents answered these questions after they observed the clothing samples. Questions about participants' selection based on product performance, including design, quality, softness, and fabrics, were included to help determine why participants selected one clothing item over another. The scenario also included price as a possible selection criteria.

The fourth section solicited details of consumers' environmental variables (environmental concerns, knowledge, attitudes, and behaviors). Items for environmental variables were adopted from previous literature (Chan, 2001; Laroche et al., 2001; Ling-yee, 1997; Bohen, et al., 1993) with the wordings changed to fit this study. Items in “environmental concerns and attitudes” employed a five-point Likert scale with 1 being *strongly disagree* to 5 being *strongly agree*. For environmental behavior, respondents designated their frequency of actions from 1, *never* to 5, *always*. Finally, participants were asked their willingness to purchase EFC, their willingness to switch from their regular brands or stores to purchase EFC, their willingness to pay more for EFC, and their past experiences of purchasing EFC.

Before collecting data, a pretest was performed with five mothers who have young children. This group interview generated preliminary impressions, ideas, and suggestions about the acceptance of EFC. The necessary corrections were made based on the opinions of the pretest participants.

Population and Sample Selection

The purpose of this study was to examine consumers’ acceptance of environmentally-friendly clothing (EFC). For young children, clothing is purchased by parents, so parents who have young children from ages 0 to 4 years were selected as the targeted population. The results from this study cannot be generalized to all consumers because this study only obtained samples from residents of Oklahoma. However, it was important to identify a target group who was likely to purchase EFC. For this study, a convenient sampling method was used. The first selected groups were Mothers of Preschoolers (MOPS) in churches. A list of MOPS groups in three cities was used to contact participants. A total of eight groups gave permission to survey them. However, this study could obtain data from only five of these groups because of cancellations due to bad weather. MOPS were located in three cities, Oklahoma City, Tulsa, and Stillwater. A second source of participants was parents whose children attend preschool programs.

The survey data gathering effort began in the middle of December, 2006 and was completed at the end of February, 2007. A surveyor visited the site to administer surveys and gave questionnaires directly to parents who were willing to participate. The obtained survey questionnaires totaled 174. After eliminating those surveys which were unusable, a total of 156 questionnaires from six sites within the three cities was used to analyze the data. Questionnaires were deemed unusable if participants did not complete selection choices or demographic information or if participants completed the beginning of the questionnaire but not the end.

Table 3.1 Product Involvement Measurement

To me [object to be judged] is			
1	Important	1 2 3 4 5	Unimportant*
2	Boring	1 2 3 4 5	Interesting
3	Relevant	1 2 3 4 5	Irrelevant*
4	Exciting	1 2 3 4 5	Unexciting*
5	Means nothing	1 2 3 4 5	Means a lot to me
6	Appealing	1 2 3 4 5	Unappealing*
7	Fascinating	1 2 3 4 5	Mundane*
8	Worthless	1 2 3 4 5	Valuable
9	Involving	1 2 3 4 5	Uninvolving*
10	Not needed	1 2 3 4 5	Needed

* indicates item is reverse scored.

Clothing Sample Selection and Buying Scenario

This study provided two sets of children's clothing as samples. Each set consisted of organic and conventional cotton clothing. Bodysuits (onesies) were selected for the sample items. Before purchasing the samples, a panel composed of university faculty was involved in refining the clothing samples to assure deviation in possible reasoning for clothing acceptance. In addition, a panel examined pricing information from online websites and brick/mortar shops to determine the average price of a similar bodysuit. After searching 35 web sites (15 organic cotton product websites and 20 conventional cotton product websites) and visiting 15 stores (in the three cities used for the survey), the price range was identified. The price of items varied depending on design and quality. For example, if the hem was double folded, the cost was higher than for a single-folded hem. The average price of an organic cotton bodysuit with a design on the front was $16.05. The average price of a conventional bodysuit with a design on the front was $9.85. An approximately 63 percent price difference existed between organic and conventional cotton clothing with similar style, quality, and functional aspects.

Initially, 4 organic cotton bodysuits and 10 conventional cotton body suits were obtained. Two of each of these were selected as clothing samples because their colors were the same (White) and both had similar designs on the front. Also, both samples had three snaps on the bottom, a lap shoulder, and double-folded hem. (Figure 6.2) Original tags and labels were removed, and the author affixed new tags to give manipulated price information to participants. The newly designed tags also contained fabric information designating organic cotton or conventional cotton.

To understand how price influences purchasing decisions, this study conducted three versions of the buying scenario: one with a 60% higher price for organic cotton clothing, one with a 30% higher price for organic cotton clothing, and one with no price information for the control group. Consumers selected one of the two currently available children's clothing samples with differing variations in ecological and price information (Table 6.3). The two experimental variables were cotton materials information and price information. Data were collected in focus groups. Each group was randomly assigned one of the three buying scenarios.

Table 3.2. Consumer Acceptance of EFC

Sample set	60% price difference		30% price difference		No price information	
Material Type	Organic cotton	Conventional cotton	Organic cotton	Conventional cotton	Organic cotton	Conventional Cotton

This buying scenario allowed the study to estimate the implicit prices of the attributed of children's clothing. In the survey, respondents selected one clothing item from each set and specified the reasons for their decision. Participants were grouped into those who accepted EFC and those who did not accept EFC. Additionally, from the reasons given, this study identified why consumers selected or did not select EFC based on product performances such as (1) design, (2) quality, (3) softness, and (4) fabrics. The study also identified how pricing determined the parents' selections based on their answers to these questions in the survey.

Statistical Analysis

Questionnaires were analyzed using the Microsoft Windows statistical package SPSS 14.0. First, descriptive statistics were used for recognizing the demographic information of respondents. Second, descriptive statistics were used again to identify participants' behaviors. Third, influential statistics including comparisons and correlations were used to examine the relationship between independent variables and dependent variables. To compare subgroups of respondents, a Chi-square was used to analyze differences among categorical data. One-way analysis of variance (ANOVA) was used to test significance in the effect of demographic information (age, income, education, and employment status) on acceptance of EFC. Factor analysis was used for evaluating both independent variables (predictors: children's clothing involvement, product performance, environmental concerns and environmental behavior) and the dependent variable (acceptance of EFC). Multiple regression and correlations analysis were used to determine whether independent variables could predict dependent variables and whether there were positive or negative relationships among variables. In addition, a reliability test was conducted on four categories: 1) involvement in children's clothing, 2) involvement in organic cotton clothing, 3) environmental concerns, and 4) environmental behavior. Cronbach's coefficient alpha was used. The result of the reliability of these characteristics measurements were sound, with the reliability coefficient ranging from .66 to .96.

CHAPTER IV

RESULTS OF INTERVIEW

This study investigated how apparel designers and manufacturers identify which apparel design and production processes they use and consider sustainable development in their work. Three designers, one owner, and one production manager in two apparel companies were selected for in-depth interviews. The results are based on analysis of the interview contents.

Descriptions of Design and Production Processes

Five apparel design personnel described their design and production processes. Apparel designers and merchandisers identified their process very similarly. First, designers conducted market research to identify consumers' needs. Designers attend trade shows, search information on the internet, and conduct national and/or international street market research. Based on the information from market research and information from trend forecasting, designers create styles and develop a concept map which includes color, style, and fabric information. This concept map is utilized as the design team selects colors and materials, makes samples, displays them, and discusses them with the marketing team. The design and marketing teams use the samples to select styles, orders, and quantities. Pre-costing is also performed during the making of the samples. If the cost is higher than expected, the teams discuss options for using less expensive materials. If it is not possible to lower the cost, the company may decide not to produce the line. Once styles have been selected, designers contact manufacturers for production. The process, from market research and design to production, generally takes three months, with the process for sample making lasting three to four weeks. After production, if products sell well in the market, the company produces additional products for reorders.

The designers' responsibilities are summarized in Table 4.1. Three of the designers take on the responsibilities of performing market research, selecting materials, creating designs and samples, and managing production. Designers who have higher positions such as head or senior designer share their responsibility and interact with merchandisers.

Table 4.1. Designer and Manufacturer Responsibilities

Title	Industrial Experience	Responsibility Description
Designer 1 (Head Designer)	11 years (A)	Performing market research; Analyzing information; Selecting designs; Deciding styles, color, and fabrics; Interacting with marketing team; Managing production; and Controlling volume
Designer 2 (Senior Designer)	6 years (B)	Performing market research; Creating samples; Deciding materials; and Managing production
Designer 3 (Junior Designer)	3 years (A)	Creating designs; Deciding accessories and details
Manager 1	15 years (B)	Interacting with design team; Managing production starting with sample making; Selecting materials; and Assigning assembly manufacturers
Owner 1	31 years (B)	Controlling all decisions including selecting yarn manufactures and assembly manufacturers.

*A and B indicate the different companies.

All three designers said that current trends are the most important deciding factor when they select materials. The head and senior designers mentioned cost as an additional factor. The opinions the manager and the owner were a little different from the designers' opinions. The manager and owner regard cost as the most important factor. Another important factor to the manager and owner is the availability of materials from suppliers which have had long term relationship with the company. When designers were asked what other information they considered important, they identified color, style and technical knowledge for fit.

The biggest challenges for companies A and B were lowering costs and producing new styles more frequently to compete with big volume international companies. One designer in company B mentioned that the quality of the clothing is more important now than in the past because current consumers know as much as apparel professionals and have better access to fashion knowledge. The designer also stated that low priced brands and upscale brands can produce similar products, however, product quality can separate the two.

Considering Sustainable Development Issues for Design

All of three of the designers had never considered that they might be responsible for realizing sustainable development. In the company, no one emphasizes environmental issues. Only one designer, who had eleven years of experience in apparel design, was aware of environmental problems in apparel production. However, he felt that there was nothing he could do as a designer to address environmental issues and that mentioning environmentally friendly production to the company's manufacturers was beyond his ability. Additionally, the designer's company was very cost conscious, and under this circumstance, employing environmentally friendly materials, which generally raises cost, was not realistic.

Both manager and owner mentioned that they were aware of the environmental problems associated with yarn dyeing and textile processing, and they acknowledged that some of the fibers they use are environmentally harmful. The two merchandisers also pointed out that current consumers are more concerned about health, but they did not know how to connect this trend to their work. They were aware that some other companies are attempting to use organic cotton or environmentally friendly dyes, but the two companies did not employ organic cotton or environmentally friendly materials because of cost problems and fear of an uncertain market demand. Two merchandisers said that if consumers were willing to purchase environmentally friendly clothing, then they would produce it. One designer in company A and a manager and owner from company B stated that they may use environmentally friendly materials in the future to appeal to consumers based on the potential health benefits associated with them. However, they said they could not promote environmentally friendly clothing based only on the environmental benefits.

According to these interviews, lack of information was the biggest reason why the designers did not work towards sustainable development. Neither company emphasized sustainable development within the organization. The designers had never considered that they could reduce environmental problems. Two designers did know of the existence of organic cotton, but one designer did not. None of the designers understood exactly what being organic meant in the context of textile manufacturing. In addition, none of the five interviewees was significantly concerned about the end of clothing's life cycle. Even if the designers had wanted to realize sustainable development in their work, they would not have known how. One designer suggested that if there was one expert familiar with sustainable development in the company, this expert could provide knowledge to the other designers and manufactures, and then they could attempt to achieve sustainable design.

CHAPTER V

C2CAD: A SUSTAINABLE APPAREL DESIGN AND PRODUCTION MODEL

MANUSCRIPT I FOR PUBLICATION

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C2CAD: A sustainable apparel design and production model

Abstract

Purpose ─ This paper is to develop and implement a new sustainable apparel design and production model, C2CAD, that provides guidelines for apparel designers and manufacturers to solve some of the sustainability problems related to apparel production.

Approach ─ The C2CAD model was developed by integrating McDonough and Braungart's "cradle to cradle" model into existing apparel design and production models. Knitwear design and production was used to implement the C2CAD model as a proof of concept. The performance and cost of the C2CAD knitwear were evaluated.

Findings ─ The C2CAD model has four main steps: a) problem definition and research; b) sample making; c) solution development and collaboration; and d) production. Following the four steps and with an international collaboration similar to current apparel industry practices, "Four-season sustainability" children's knitwear was developed. Produced with an acceptable manufacturing cost, the products have good mechanical and color fastness performance.

Practical implications ─ The C2CAD model provides practical guidelines for apparel designers and manufacturers and allows them to address all three pillars in sustainable development: economic development, social development, and environmental protection.

Originality/value ─ The C2CAD is the first apparel design and production model that emphasizes sustainability in addition to functional, expressive, and aesthetic considerations. The production process of "4-season sustainability" children's knitwear demonstrated the implementation of C2CAD model in sustainable apparel design and production.

Keywords: sustainable, apparel design and production, model, cradle to cradle, knitwear

Article type: Research paper

Introduction

The goal for sustainable development is human health and well-being in economic, environment, and social systems (Crofton, 2000). However, the apparel industry is a major contributor to environmental problems from textile material manufacturing through apparel production to landfills replete with synthetic fabrics. The production of cotton can cause major environment damage since a large quantity of pesticides, fertilizers, and defoliants are used in cotton fields. In 1999, cotton was the second most heavily pesticide sprayed crop (behind only corn) with approximately 81 million pounds of pesticide applied to upland cotton in the U.S. (Marquardt, 2001). Some of these chemicals are carcinogens and have severely contaminated our water supply. In manufacturing, the textile industry consumes a large quantity of water and generates large volumes of waste. On average, approximately 160 pounds of water (20 gallons) are required to produce 1 pound of textile product. Textiles are also a chemical-intensive industry and the wastewater from textile processing contains processing bath residues from preparation, dyeing, finishing, slashing, and other operations (U.S. Environmental Protection Agency, 1996).

There are several process models very useful in apparel designing and manufacturing (Watkins, 1988; Lamb & Kallal, 1992; May-Plumlee & Little, 1998; LaBat & Sokolowski, 1999). Lamb and Kallal (1992) proposed the FEA consumer needs model that set functional, expressive, and aesthetic (FEA) considerations as the design criteria for different users/markets. This model has been widely used in apparel design and production. However, as far as this project reviewed, no apparel design and production model considers the designer's role in environmental sustainability into consideration.

The purpose of this paper is to document the development and implementation of a new apparel design and production model, which integrates the sustainable design into existing apparel design and production models. As early as 1970, Victor Papanek saw the role designers could play to solve environmental problems. He wrote that in this age of mass production when everything must be planned and designed, design has become the most powerful tool with which man shapes his tools and environments (Papanek, 1971). It is this project's intention that the new sustainable apparel design and production model will provide guidelines for apparel designers and manufacturers in their work and solve some of the environmental problems related to apparel production. In this paper, knitwear design and production is used in the implementation of the new model as a proof of concept.

Development of the Sustainable Apparel Design and Production Model

Apparel design and production models

LaBat and Sokolowski (1999) reviewed a variety of design processes, including architecture and environment design, engineering design, industrial product design and clothing design, and found common factors among these processes. As a result, they developed a three-stage textile product design process that provides guidelines for how creative thinking evolves in the textile product design process (LaBat and Sokoloskwi, 1999). According to this model, the apparel design process is divided into three phases:

a. Problem definition and research – The design team attempts to define the problems and conducts research on users' and markets' needs.
b. Creative exploration – The design team generates ideas, creates and evaluates prototypes.
c. Implementation – Focuses on the reality of producing the product for marketing, successful sales, and being used by the ultimate consumers.

LaBat and Sokolowski (1999) demonstrated the application of the three-stage design process in a cooperative industry-university project to redesign an athletic ankle brace. They also mentioned that this process has particular utility for university designers conducting a project for an industry client (LaBat and Sokoloskwi, 1999).

May-Plumlee and Little (1998) recognized the importance of the product development process for apparel manufacturing firms. They reviewed models of the product development process used in apparel industry and developed a comprehensive model, no-interval coherently phased product development model for apparel (NICPPD), based on the current practices found in the U.S. apparel industry (May-Plumlee and Little, 1998). This model has six phases: a) line planning and research; b) design/concept development; c) design development and style selection; d) marketing the line; e) pre-production; and f) line optimization. Traditionally, product development models were sequential models, in which the next step occurs when the previous step is finished. Sequential models do not allow for "backward movement" and communication between steps. To the contrary, May-Plumlee and Little's NICPPD model is a non-sequential model that includes *approved* and *not approved* stages and emphasizes communication. For instance, when the design team or production team discovers problems, the production process can move backward, allowing them to find solutions.

Cradle to cradle model

Every product has a life cycle. The traditional manufacturing model is a one-way "cradle to grave" model that does not consider the materials after the use and creates a large amount of waste and pollution. McDonough and Braungart introduced a model of "cradle to cradle" design in which products can be designed from the onset so that, after their useful lives, they will provide "nourishment" for something new. Materials can be conceived as "biological nutrients" that will easily reenter the water or soil without depositing synthetic materials and toxins, or as "technical nutrients" that will continuously circulate as pure and valuable materials within "closed-loop" industrial cycles, rather than being "downcycled" into lower-grade materials (McDonough and Braungart, 2002). This "cradle to cradle" model provides designers with a new way to design products and eliminate many environmental problems at the very beginning of the product life cycle — during the design phase. Key to "cradle to cradle" design is the chemical and material assessment protocol that allows designers to assess chemical ingredients against multiple human and environmental health and safety endpoints. The criteria used to assess chemicals include: carcinogenicity, endocrine disruption, mutagenicity, reproductive toxicity, teratogenicity, acute/chronic toxicity, irritation, contents of organohalogens and heavy metals, fish/algae/daphnia toxicity, persistence/biodegradation, bioaccumulation, and ozone depletion/climatic relevance

(McDonough, et al., 2003). Once assessed, the ingredients are flagged using color coding to facilitate decision making. Red indicates an ingredient of potentially high hazard. Yellow is moderate to low inherent hazard and green indicates that the ingredient is inherently benign for the application. Orange designates ingredients for which necessary data are missing. "Cradle to cradle" design incorporates aspects of green chemistry and green engineering by selecting ingredients and materials that are both inherently benign and capable of behaving as biological and/or technical nutrients within material "metabolisms", thus eliminating the concept of waste (McDonough, et al., 2003). "Cradle to cradle" design has been successfully applied by some textile and apparel manufacturers such as Nike, DesignTex and Shaw Industries (McDonough and Braungart, 2002; Cao et al., 2006).

Development of the sustainable apparel design and production model: C2CAD

In this paper, "cradle to cradle" model (McDonough and Braungart, 2002) was integrated into existing apparel design and production models (LaBat and Sokoloskwi, 1999; May-Plumlee and Little, 1998) to develop a sustainable apparel design and production model, C2CAD (cradle to cradle apparel design). C2CAD, as illustrated in Figure 1, has four main steps: a) problem definition and research; b) sample making; c) solution development and collaboration; and d) production.

"take in Figure 5.1"

In step 1 of C2CAD, problem definition and research, designers define problems and analyze market and company situations. Designers need to understand the users' functional, aesthetical, and economical needs. Conducting research to satisfy these needs and generating design ideas, are necessary in this step. At the end of this step, an apparel style should be decided.

Step 2, sample making, includes "material selection and testing" and "cost and design evaluation." According to Pitimaneeyakul et al. (2004), the sample making process is essential to determining whether products can be marketable and producible. A "sample making" step can help companies evaluate the design before they invest significant money and time on real production. In material selection and testing, designers assess chemical ingredients based on the "cradle to cradle" chemical assessment protocol and materials based on their feasibility as biological or technical nutrients. Designers will phase out "red" materials and use more "green" materials. Materials are defined as either biological or technical nutrients. For biological nutrients, disposal without negative environmental impact is necessary. For technical nutrients, designers must decide upfront on the pathways for reuse or recycling of materials after the apparel's use. If a product is made from a mixture of biological and technical nutrients, or a mixture of different technical nutrients, then separation processes (design for disassembly) are considered so that after separation, different nutrients can follow different pathways for disposing, reuse or recycle (McDonough and Braungart, 2002). In cost and design evaluation, apparel producers will evaluate function, performance, fit, style, and estimate cost. If the sample does not meet the requirements for these criteria, the design will be modified and re-evaluated.

Step 3 of C2CAD is solution development and collaboration. In current industrial divisions, most apparel manufacturers do not produce the textile fabrics, dyes, and other apparel materials. Co-development of fabric with vendors is a component in May-Plumlee and Little's NICPPD model (May-Plumlee & Little, 1998). In the "cradle to cradle" model, Braungart (2002) proposed "intelligent materials pooling", which emphasizes collaborative approaches, such as sharing knowledge and resources, as important strategies in sustainable development. In the C2CAD model, apparel designers and manufacturers will collaborate with other companies in the supply chain to solve materials problems, such as phasing out a "red" material.

The last step, step 4 in C2CAD, is production. Unlike other apparel production models, C2CAD considers sustainability in production. In addition to safety of material inputs and sustainable material flows, considerations regarding sustainability in production include energy use, air emissions, water, and solid waste. Collaborations with other industries, such as companies that produce renewable energy or use solid waste from apparel production as their biological nutrients or raw materials, are needed to reduce or eliminate harmful impacts during production.

Implementation of C2CAD in knitwear design and production

Knitwear design and production is used to implement C2CAD as a proof of concept. The reason of selecting knitwear is that knitwear is made by intertwining yarns in a series of connected loops. Therefore, the observation of almost all processes from the yarn to the final product in knitwear production is possible. Also, the knitwear industry is one of most important producers of the apparel industry. Knitwear, like other apparel products, generates environmental problems throughout its life cycle from raw materials through production to using and disposing. This study followed the steps in C2CAD model in prototype knitwear design and production.

Step 1: problem definition and research

The consumers of children's wear were identified as a target market and the designs of knitwear were created. Because children are vulnerable to the potential toxins such as unsafe dyes used in apparel, one of key points of sustainable development is to preserve the environment for our children. In the past, parents who had young children were very value conscious and did not want to spend a lot of money on clothing for children because children quickly grow but their clothing (Frings, 2005). However, recent trends for young children's clothing have changed. Sales of infant and toddler apparel have increased over the last five years while the birth rate has decreased (Verdon, 2003). One of the reasons for this trend could be that there are smaller numbers of children in families; thus, children's parents and grandparents spend more money on clothing gifts (Verdon, 2003). Another possible reason is that many of today's parents have their first child when they are in their mid-30's after they have achieved stable careers earning more disposable income (Prendergast and Wong, 2003). Annual birthrate in the U.S. is 4 million. The steady birthrate attracts companies to pursue children's market. Even though there are many design requirements for children's wear, this project includes ease of dressing, washability, durability, and versatility as design requirements (Frings, 2005). Keeping these design requirements in mind, the design theme for this project was "Four-season sustainability" — spring, summer, fall and winter knitwear apparel for children using the C2CAD model.

Step 2: Sample making

Materials selection and testing along with cost and design evaluation were conducted for the development of C2CAD samples. This project used 100% organic cotton fibers which were grown without harmful chemicals. This made the whole knitwear product a biological nutrient. For biological nutrients, all chemicals used should be able to easily re-enter the water or soil without depositing toxins (McDonough and Braungart, 2002). Eight different colors were incorporated in the design and utilized five natural dyes and three synthetic dyes. The five natural dyes were indigo (light blue), brazilwood (pink), logwood (brown), weld (light yellow), and fustic (dark green). The three synthetic dyes were obtained from Ciba Specialty Chemicals. Yarns in all eight dyes were batch dyed. The only mordant used to help fix natural dyes on the yarns was salt (NaCl). As this study mentioned earlier and Braungart (2002) proposed, this study needed collaborative approaches to share knowledge and resources because of the unavailability of synthetic dyes' information. This circumstance explained the dotted line from *ingredient analysis* in step 2 to step 3 through *not approved* in Figure 1. Therefore, by collaborating with the partners for this project, it was possible to evaluate the three synthetic dyes to make sure they are categorized into "green" (see step 3, next paragraph, for details). In the evaluation process, this study compared the organic and traditional cotton yarns and fabrics and evaluated the dyeing performance as discussed in the next section, Evaluation of the "Four-season sustainability" children's knitwear.

Step 3: solution development and collaboration

While evaluating the three synthetic dyes, this project collaborated with the partners Green Blue Institute (GreenBlue) in Virginia, USA and Environmental Protection Encouragement Agency (EPEA) in Hamburg, Germany. The EPEA further partnered with dye manufacturer Ciba Specialty Chemicals. Ciba provided three synthetic direct dyes, Solophenyl Blue FGLE 220%, Solophenyl Yellow ARLE 154%, and Solophenyl Scarlet BNLE 200% and their Material Safety Data Sheets (MSDS), based on European regulations, which contain more documentation on eco-toxicological properties than those used in the U.S. Ciba also provided EPEA with proprietary information on their dye structures and syntheses. Though EPEA did not release Ciba's proprietary information directly, EPEA assured that they support the use of these three dyes for biological cycles based on knowledge on structure and synthesis pathways. With the advising from GreenBlue and based on the toxicological information on MSDS sheets and EPEA's biological nutrient assurance, this project concluded these 3 synthetic dyes have no known adverse effect on human and environmental health ("green" category). This process demonstrated how apparel designers and producers can collaborate with chemical manufacturers and third party institutions on chemical evaluation to assure inherent safety.

Step 4: production

The knitwear production process is divided into four parts: dyeing yarns, knitting fabrics, assembly, and setting. It is possible to dye yarns and knit fabrics by the designers. However, for other processes, special equipment and facilities are needed. Thus, "Four-

Season Sustainability" knitwear working sketches and dyed organic cotton yarns were sent to the production partner, Maeil, a knitwear manufacturer in Kyunggi, Korea. Using an industrial full-fashion intarsia knitting machine, Maeil produced the "Four -Season Sustainability" knitwear as shown in Figure 4.2.

"take in Figure 5.2"

Apparel production is a global industry, with manufacturers in both developing and developed worlds (Glock and Kunz, 1995). This project demonstrated the importance of international partnership, as illustrated in Figure 4.3, in the implementation of C2CAD model for sustainable apparel production. This project had apparel designers and performance evaluators in the U.S., third party chemical evaluation consultants in the U.S. (GreenBlue) and Germany (EPEA), dye manufacturer (Ciba) headquartered in Switzerland with branches in the U.S., and apparel producer (Maeil) in Korea. This global sourcing, in which clothing is designed in the U.S. and produced in another country, is quite similar to current industry practices. A close collaboration among all the partners, directly and indirectly, is critical in the successful implementation in C2CAD to accomplish sustainable apparel production.

"take in Figure 5.3"

Evaluation of the "4-Season Sustainability" Children's Knitwear

Performance evaluation

In order to evaluate the performance of the "4-season sustainability" children's knitwear, the yarns to be used for the C2CAD samples were dyed and tested. Four tests, breaking load, elongation, pilling, abrasion resistance and color fastness of "biological nutrients" yarns and knit fabrics were conducted. To compare organic and traditional cotton yarns, 100% organic and traditional cotton carded yarns with the same thickness (10/2: cotton number 10 and 2 plies) were purchased. Both types of yarns are open end, unwaxed, undyed, and unmercerized. The testing methods were in accordance with American Society for Testing and Materials (ASTM, 2004) and American Association of Textile Chemists and Colorists (AATCC, 2004) standards as summarized in Table 5.1. Yarn strength (dyed and undyed) was evaluated using breaking load and elongation test. For tests requiring fabric, undyed and batch dyed yarns were knitted on a flatbed knitting machine in the same gauge as the C2CAD samples. These knitted fabrics were used for pilling, abrasion resistance and color fastness (light and laundering) tests. The test results are summarized in Table 5.2.

"take in Table 5.1"

The t-test was used to statistically compare the breaking load, elongation, pilling, abrasion resistance and color fastness of the organic and non organic cottons. For yarn strength, non organic cotton yarn is significantly stronger and has significantly higher elongation than organic cotton yarn. Both organic and traditional cotton knit fabrics have no pilling after the tumble pilling test; thus, there is no significant difference between organic and traditional cotton knit fabrics in abrasion resistance. Because children grow rapidly, their clothing is used for a relatively short time; therefore, researchers for this project believe the mechanical properties of organic cotton yarns and fabrics are acceptable for or exceed the expectations for the target market.

For color fastness, there is one significant difference between organic cotton and traditional cotton: color change after laundry. The evaluation of color fastness is a subjective process with a rating of 5 for no color change or transference to multifiber test fabric. A rating of 1 for color change or transference indicates a sever difference. The results showed that after laundry, organic cotton knit fabric has significantly less color change (better color fastness) than traditional cotton knit fabric. No significant differences exist between organic and traditional cotton knit fabrics with regards to colorfastness to light and to crocking. Colorfastness after laundering (AATCC 61) all fastness ratings are 3 or higher for organic or traditional cotton fabrics. This indicates that the natural dyes and safe synthetic dyes used in this project can deliver good dyeing quality that is acceptable for apparel products.

"take in Table 5.2"

Cost analysis

Due to the globalization of the apparel industry, it is difficult to analyze the production cost for a specific garment. The cost of a garment can vary significantly depending on manufacturers and suppliers of raw materials and chemicals. Generally, volume manufacturers supply the lowest priced goods (Frings, 2005). In the apparel industry, materials, production pattern making, assembly, finishing, freight, and duty are all cost considerations (Frings, 2005). In order to compare the cost of organic and traditional cotton yarns, this project ordered the same amount, 100 pounds of the same thickness (10/2) of organic and traditional cotton yarns. The cost of the organic cotton yarn was $5.95/pound, and the traditional cotton yarn was $8.00/pound. Both types of yarns were produced in the U.S. At the beginning of the project, project team members expected that organic cotton yarns would cost more than traditional cotton yarns. However, this project bought the organic cotton from a company with a shorter supply chain, which resulted in a lower cost. This cost difference between organic and traditional cotton yarns used in this project demonstrates that environmental friendly materials do not necessarily be more expensive for apparel producers if materials go through a proper or short supply chain. Except for yarn cost, all other cost considerations were the same for both organic and traditional cotton knitwear.

The cost analysis for "4-Season Sustainability" children's knitwear is summarized in Table 4.3. In this analysis, the cost of dyeing was not considered because it is very difficult to evaluate the cost of a laboratory-scale dyeing. If the project order dyed yarns for apparel production, a typical process in the apparel industry, the prices for undyed and dyed cotton yarns are about the same. This knitwear was produced in Korea, and the total cost was about $7.08 for a short sleeve knitwear and $7.38 for a long sleeve one. Compared with mass production in the U.S. apparel industry, a smaller order is typical in Korea, which resulted in a relatively higher price for each garment.

"take in Table 5.3"

Discussions, Conclusions and Recommendations

According to the 2005 World Summit Outcome Document (United Nations, 2005), the interdependent and mutually reinforcing pillars of sustainable development are economic development, social development, and environmental protection. This project proposed a sustainable model C2CAD by integrating "cradle to cradle" model into existing apparel design and production models. As summarized in Table 4.4, C2CAD model allows apparel designers and manufacturers address all three pillars in sustainable development.

"take in Table 5.4"

Using the C2CAD model, apparel designers and manufacturers select chemicals and materials based on their inherent human and environmental health and safety. Therefore, employee occupational safety and the living quality of the people living in the local communities will be improved. Apparel products made from inherently benign materials and chemicals, the health of consumers, especially these people vulnerable to toxins such as children, can be improved. With materials designed to cycle safely at the end of the products' life, the C2CAD model also helps diminish resource consumption by the apparel industry. Without harmful air, water, and solid waste release from apparel manufacturers, both the manufacturer and the local community will save a lot of money in pollution prevention and treatment for the short and long term. With current knowledge, implementing material assessment protocol in "cradle to cradle" model (McDonough et al., 2003) costs much for chemical toxicity research and new material development. Like “cradle to cradle” model and “intelligent materials pooling” (Braungart, 2002), the C2CAD model emphasizes the importance of industrial collaboration and knowledge sharing (step 3 of C2CAD). So, this short term cost in material research will eventually turn out to be a long term saving in many aspects such as pollution treatment and material cost.

The C2CAD model was developed and implemented in knitwear design and production. The production of “4-season sustainability” children’s knitwear demonstrated that following the C2CAD model, sustainable apparel products with acceptable performance and cost can be produced. However, knitwear production is only one section of apparel industry. There are differences in design and production between knitwear production and other apparel production sections such as woven fabric products. Knitwear production is relatively simpler than others. Though it is a good strategy to use knitwear production as a proof of concept, implementing C2CAD in other sections of apparel production should be further studied.

The material used in the “Four-season sustainability” children’s knitwear is 100% cotton, which is a biological nutrient in the “cradle to cradle” model. Many apparel products contain technical nutrients, which are mainly synthetic materials, or a mixture of biological nutrients and technical nutrients. According to the cradle to cradle model, the best strategy for effective material management regarding a mixture of biological and technical nutrients in a product is to “design for disassembly,” or design a product to be dismantled for easier maintenance, repair, recovery, and reuse of components and materials (McDonough and Braungart, 2002). This project incorporated the concept of “design for disassembly” in the step 2 of C2CAD model. However, there is no research on the implementation of design for disassembly in apparel design and production. Therefore, future research on the application of "design for disassembly" in apparel design and production is needed to effectively manage the mixture of biological and technical nutrients in apparel products.

References

AATCC (2004), AATCC Technical Manual, *American Association of Textile Chemists and Colorists*, North Carolina.

ASTM (2004), Annual Book of ASTM Standards, Vol 07, *American Society for Testing and Material*s, Philadelphia.

Braungart, M. (2002), "Intelligent materials pooling: evolving a profitable technical metabolism", available http://www.mbdc.com/features/feature_sep2002.htm.

Cao, H., Frey, L., V., Farr, C. A. and Gam, H. (2006), An environmental sustainability course for design and merchandising students, *Journal of Family and Consumer Sciences, 98*(2), 75-80.

Crofton, F. S. (2000), Educating for sustainability: opportunities in undergraduate engineering, *Journal of Cleaner Production*, 8(5), 379-405.

Frings, G. S. (2005), *Fashion: from Concept to Consumer* (8th ed.), Prentice Hall, New Jersey.

Glock, R. E. and Kunz, G. I. (1995), *Apparel Manufacturing* (2nd ed), Prentice Hall, New York.

LaBat, K. L. and Sokolowski, S. L. (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.

Marquardt, S. (2001), "Organic cotton: production and marketing trends", *Proceedings of Beltwide Cotton Conference*, Anaheim, CA, January 9-13, 2001.

May-Plumlee, T. and Little, T. J. (1998), No-interval coherently phased product development model for apparel, *International Journal of Clothing Science and Technology*, *10*(5), 342-364.

McDonough, W. and Braungart, M. (2002), *Remarking the Way We Make Things: Cradle to Cradle*, North Point Press, New York.

McDonough, W., Braungart, M., Anastas, P. T. and Zimmerman, J. B. (2003), Applying the principles of green engineering to cradle-to-cradle design, *Environmental Science and Technology*, *37*, pp. 435A-441A.

Papanek, V. (1971), *Design for the Real World: Human Ecology and Social Change* (1st American ed.), Pantheon Books, New York.

Pitimaneeyakul, U., LaBat, K. L. and DeLong, M. R. (2004), Knitwear product development process: a case study, *Clothing and Textiles Research Journal,22*(3), 113-121.

Prendergast, G. and Wong, C. (2003), Parental influence on the purchase of luxury brands of infant apparel: an exploratory study in Hong Kong, *Journal of Consumer Marketing, 20*(2), 157-169.

United Nations (2005). World summit outcome. Available online at http://ec.europa.eu/comm/external_relations/un/docs/050915_un_summit.pdf.

U.S. Environmental Protection Agency (1996), “Best management mractices for pollution prevention in the textile industry”, EPA Manual 625R96004, available http://www.p2pays.org/ref%5C02/01099/0109900.pdf.

Verdon, J. (October 4, 2003). “Sales of baby clothing increases over 20 percent in 2002”, The Record (newspaper), Hackensack, New Jersey, USA.

Watkins, S. M. (1988), Using the design process to teach functional apparel design, *Clothing and Textiles Research Journal*, *7*(1), 10-14.

Table 5.1. Cotton Yarns and Fabrics Performance Test Procedures

Performance	Samples	Test method [a]	Equipment	Replicates
Strength	7 yarn samples for each type of yarn (undyed, dyed with 3 synthetic dyes and 3 natural dyes)	ASTM D2256 [a]	Thawing-Albert EJA Universal Materials Testing Instrument	5
Abrasion resistance	1 fabric sample (undyed) for each type of yarn	ASTM D3884 [b]	Taber Model 503 Abraser	3
Resistance to pilling		ASTM D3512 [c]	Atlas Random Tumble Pilling Tester	3
Laundry fastness	8 fabric samples for each type of yarn (dyed with 3 synthetic dyes and 5 natural dyes)	AATCC 61 [d]	Atlas Launderometer	9 (3 evaluators, 3 ratings)
Light fastness		AATCC 16 [e]	Atlas Suntest XLS	
Crocking fastness		AATCC 116 [f]	Atlas Crockmeter CM-5	6 (3 evaluators, 2 ratings)

Note: a. ASTM D2256: Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method (ASTM, 2004).
b. ASTM D3884: Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method) (ASTM, 2004).
c. ASTM D3512: Standard Test Method for Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Random Tumble Pilling Tester (ASTM, 2004).
d. AATCC 61: Colorfastness to Laundering, Home and Commercial: Accelerated (AATCC, 2004).
e. AATCC 16: Colorfastness to Light (AATCC, 2004).
f. AATCC 116: Colorfastness to Crocking: Rotary Vertical Crockmeter Method (AATCC, 2004).

Table 5.2. Summary of Performance Test Results

		Yarn type	Mean	t
Breaking load & elongation (n=35)	Strength (pounds)	Organic	2.61371	-11.080*
		Non organic	3.26057	
	Elongation (%)	Organic	10.96266	-3.558*
		Non organic	11.81909	
Abrasion Resistance (n=12)	% fiber lost after XX cycles	Organic	1.25	.266
		Non organic	1.21	
Color fastness after laundry (n=72)	Color fading	Organic	3.174	3.524*
		Non organic	2.715	
Color transference To multifiber test fabric (n=72)	Acetate fibers	Organic	4.403	1.372
		Non organic	4.271	
	Cotton fibers	Organic	3.257	.266
		Non organic	3.201	
	Nylon fibers	Organic	3.701	.000
		Non organic	3.701	
	Polyester fibers	Organic	4.403	.484
		Non organic	4.354	
	Acrylic fibers	Organic	4.458	-1.064
		Non organic	4.556	
	Wool fibers	Organic	4.604	.425
		Non organic	4.576	
Light Fastness (n=72)	Color fading	Organic	4.326	1.304
		Non organic	4.139	
Crocking (n=48)	Dry	Organic	4.458	.292
		Non organic	4.417	
	Wet	Organic	3.615	1.366
		Non organic	3.375	

* $p < .05$

Table 5.3. Cost analysis of Children's Knitwear Produced in this Project

Process	Cost	Place
Organic cotton Yarn	$5.95 per pound Short sleeve (0.35 pound: 0.35 x 5.95 = $2.08) Long Sleeve (0.40 pound: 0.40 x 5.95 = $2.38)	In the US
Production pattern making	$2.5-$3 per piece (300 pieces)	In Korea
Assembly and finishing	$2.5 per piece (300 pieces)	In Korea
Total	$7.08 short sleeve $7.38 long sleeve	

Table 5.4. Addressing 3 Sustainability Pillars in the C2CAD Model

Elements	Features and Issues
Economic development	Save apparel manufacturers lots of money in pollution prevention and treatment; Improved company image in society and manufacturer competitive edge in the apparel market.
Social development	Better occupational safety and health for employees; Better environment and living quality for local communities; Better health for users.
Environmental protection	Reduced environmental impact of the apparel industry by reducing the using of toxic chemicals; Cyclic material management in the apparel industry, thus diminishing resource consumption.

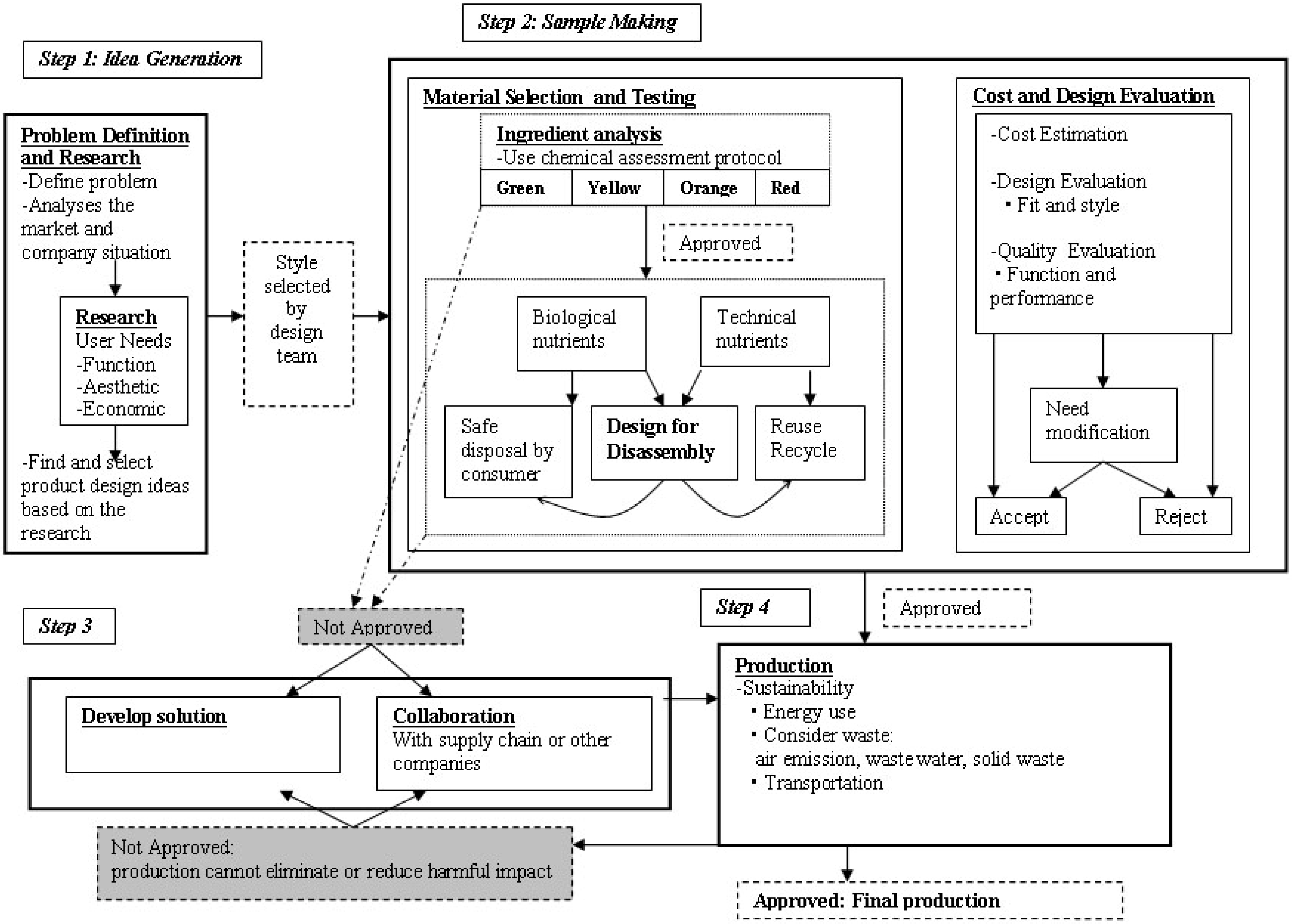

Figure 5.1. C2CAD Model for Sustainable Apparel Design and Production

Figure 5.2. "4-Season Sustainability" Children's Knitwear. Top row: original designs generated on computer. Bottom row: photographs of actual knitwear produced by Maeil.

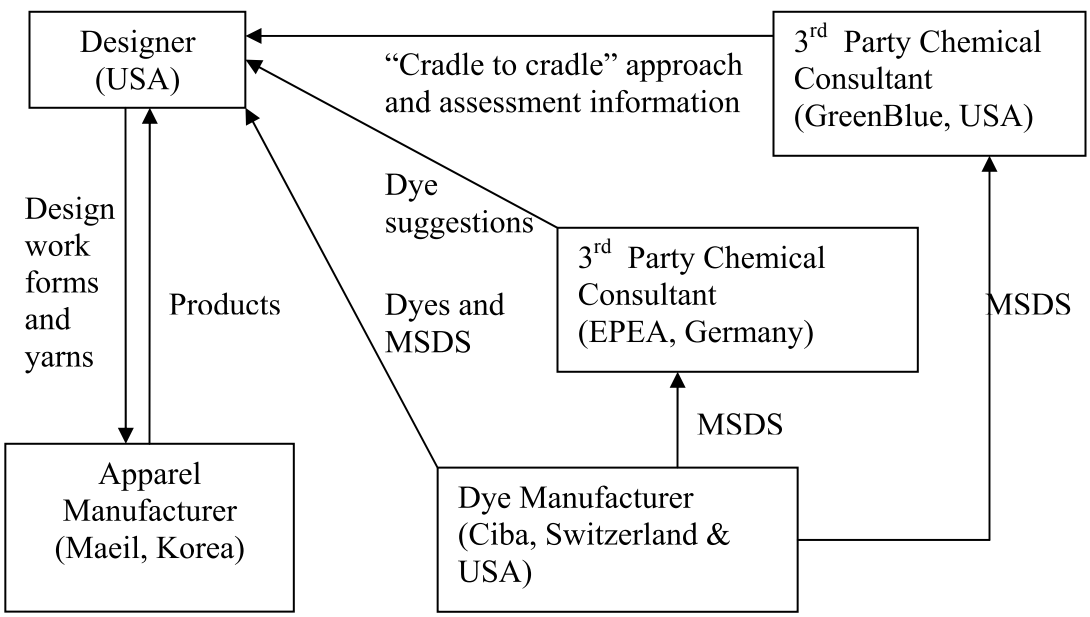

Figure 5.3. International Collaboration in the "4-Season Sustainability" Knitwear Production

CHAPTER VI

PARENTS' ACCEPTANCE OF ENVIRONMENTALLY FRIENDLY CHILDREN'S CLOTHING

MANUSCRIPT II FOR PUBLICATION

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Abstract

Purpose – The purpose of this study was to examine parents' purchasing behavior and preferences of children's clothing characteristics to understand their acceptance of children's environmentally friendly clothing (EFC).

Approach – A survey was conducted to collect data on consumer acceptance of environmentally friendly clothing. The sample for this study was mothers who have young children ages 0 to 4 years. Socio-demographics, product involvement, price premium, product performance, and environmental aspects were the underlying determinants of the consumers' acceptance of EFC.

Findings – The findings revealed that the price premium and product performance significantly impacted the acceptance of EFC, while socio-demographics and product involvement were not related to the acceptance of EFC. This study also confirmed previous findings that environmental concerns are related to greater acceptance of EFC.

Practical implications – As the market for environmentally friendly clothing expands, studies of the determinants of consumer opinion on EFC are necessary. Currently, little research exists related to purchasing behaviors of sustainable apparel products. Findings from this study generate important knowledge of consumer EFC purchasing behaviors.

Keywords: environmentally friendly clothing, children's clothing, organic cotton

Article type: Research paper

Introduction

Consumers' environmental concerns are growing continually, and increased green consumerism has put pressure on companies to be more aware of environmental friendly practices (D'Souza, 2004; Butler & Francis, 1997; Kim & Damhorst, 1998). As a result, environmental practices have become more important as marketing strategies for companies. Despite the growing necessity of environmental practices in the apparel industry, there is little research aimed at understanding consumers' acceptance and preferences of environmentally friendly clothing (EFC) or how it can achieve a favorable evaluation in the marketplace.

Previous green marketing literature states that consumers who are environmentally conscious will purchase green products (Fraj & Martinez, 2006; Kim & Damhorst, 1998; Zimmer, Stafford & Stafford, 1994). In addition, Gardyn (2003) reported the result from a nationally representative poll of 1,000 adults in which 70 percent of consumers were more likely to buy products made from companies with a more environmentally friendly business strategy. However, this increased environmentally prudent consumption did not extend to apparel purchasing behaviors.

Consumers do not purchase green apparel products because of higher prices, few choices, aesthetic and functional disadvantages, lack of information, and uncertainty about their actual benefits to the environment (Meyer, 2001). However, if the benefit is for their children, parents showed higher interest on organic fabric clothing (Nolan, 2006). These previous studies illustrate the need for an understanding of consumers' opinions regarding an apparel company's EFC. Therefore, the purpose of this study is to examine the underlying determinants of the consumer's acceptance of EFC to provide recommendations to apparel companies wanting to produce environmentally friendly clothing. Specifically, this study investigated the acceptance of children's EFC. Consumers who have young children may be one of the consumer groups most sensitive to environmental risks, such as pesticide residues and toxic dyes on cotton fabric based on concern for their children's health and for the future of their children's world. The examination of the acceptance of children's EFC will contribute to an understanding of why consumers accept EFC whether because of their individual environmental concerns, individual socio-demographics, price premiums, product involvement, and/or product performances.

Literature Review

Fishbein and Ajzen's theory of reasoned action (1975) was considered when approaching this study of consumer acceptance of apparel being produced using environmentally sustainable materials. According to this theory, a person's beliefs are developed by "direct observation and information received from outside sources" (p.14). These beliefs also influence a person's attitude, meaning positive or negative evaluation of an object. Because attitudes help determine intentions, this study employed attitudes as a factor which influences individual behavior. In addition, other factors such as involvement on children's clothing and children clothing purchasing behaviors were examined to understand costumers' acceptance of EFC.

The Influential Factors of Consumers' Environmentally Friendly Clothing Purchasing Decisions

This study identified several factors that may influence consumers' acceptance of EFC. These factors include environmental concerns, socio-demographics, price premium, product involvement, and product performance.

Environmental Concerns and Socio-demographics

Increasing concerns about food safety have caused the dramatic growth of the organic food industry in recent years. In 2002, the consumption of natural and organic food in the US equaled $13.5 billion, 8.9% higher than in 2001 (Murphy, 2004), and as of 2005, the annual rate of growth of the organic market was about 20% (Berry, 2005). Previous literature has found that consumers who have more concerns about the environment purchase more green products (Lannuzzi & Haviland, 2006; Diamantopoulos, et al., 2003; Zimmer et al., 1994). Recent research has also suggested that because there is currently more information available about environmental problems, today's consumers are more conscious about negative health and environmental impacts from pollution (Murphy, 2004).

Some literature indicates that demographic and socio-demographic information can be used to estimate environmental concern. Diamantopoulos, et al., (2003) employed gender, marital status, age, income, family size, education, and social class as indicators. Similarly, Butler and Francis (1997) also employed socio-demographic information to define the ecologically-concerned consumer. They found that consumers who favor environmental regulations, those who are older and/or who have families, considered the environmental impact of clothing production and showed a higher interest in clothing conservation. They conducted a path analysis to observe the influential relationship among general environmental attitudes, clothing and environmental attitudes, and clothing purchase behavior. Their results showed that clothing conservationist factors influenced environmental purchasing behavior. Consumers who cared about drained resources and environmental impacts from clothing production showed higher environmental purchasing behavior.

While Butler and Francis (1997) did not find a direct relationship between higher education and increased environmental purchasing, they did find that less educated consumers cared less about environmental impacts from clothing production. Therefore, because education level helped determine environmental concern, it had an indirect effect on environmental purchasing behavior. A study by Bohlen et al, (1993) showed that better educated consumers had greater environmental concerns. Ling-yee (1997) investigated the ecological attitudes of Hong Kong consumers and found that "people who are male, those who earn higher income, and people who have high involvement in the health food category, engage in more extensive green product-related information search and purchase green products more frequently" (p.50). In another study, Bjørner, Hansen, and Russell (2004) explored whether environmental labels affect purchasing decisions for toilet paper. They discovered that environmental labeling had a significant effect based on consumers' gender and the presence of children in the household but not based on their income or education. Consumers who were female and had children were more likely to purchase environmentally labeled products.

Researchers' other approach for determining environmental concern involved measuring environmental attitudes, knowledge, and behavior. Bohlen, et al. (1993) developed three indicators—knowledge about environmental issues, attitudes about the environment, and environmentally sensitive behavior—to measure ecological concerns in accordance with previous literature. They also divided environmentally sensitive behavior into two parts: 1) non-purchasing environmental behavior, for example, recycling, and 2) purchasing behavior.

According to Fishbein and Ajzen (1975), a person's attitudes, which influence behavior, are built by learning, i.e. past experiences, concerns, information, and social pressure. Therefore, understanding consumers' environmental concerns and socio-demographic information is essential to understanding both attitudes toward EFC and purchasing decisions.

Price Premium

Consumers' attitudes toward organic cotton products vary depending on the increased price of the organic products. Most consumers, 81% of Bhate and Lawler's (1997) respondents, said that EFPs are expensive, but they frequently or sometimes purchased these products. Furthermore, some consumers perceived price premium as a guarantee of quality and safety (Jones et al., 2001).

Anderson et al. (2005) conducted an experiment on university students' purchasing behavior of eco-labeled versus normal pencils. Both pencils had the same color and design. When the two types of pencils had the same price, the eco-labeled pencils sold better. When the eco-labeled pencils were priced 20% higher, the number of the two types of pencils sold was statistically similar. When the eco-labeled pencils were priced double the normal pencils, the number sold decreased but still equaled 30 percent of total sales. The price evidently influenced pencil purchasing, but some consumers were willing to pay more for environmentally friendly products. In addition, a post-purchase survey found that not only prices influenced purchasing decisions, but also the fact that consumers did not see any actual environmental benefits from purchasing eco-labeled pencils.

Laroche et al. (2001) investigated the demographic, psychological, and behavioral profiles of consumers to identify which consumer types were willing to pay more for environmental-friendly products. They found that married females with at least one child were the most willing to pay more for environmental products. This result indicated that having children can motivate parents to behave ecologically because parents are aware of environmental impacts on their children's future. However, Laroche et al. (2001) did not identify how much more consumers will pay. Nimon and Beghin (1999) collected data from apparel catalogue retailers and found that consumers were willing to pay about 33.8% more for organic cotton products. In addition, consumers were willing to pay between 13% and 18% more for environmentally-friendly toilet paper (Bjørner, et al., 2004). The information on consumers' reaction to price will help apparel companies determine the right price ranges in which to produce EFC.

Product Involvement

"Consumer involvement is defined as the perceived importance or interest attached to the acquisition, consumption, and disposition of good, service, or idea;" therefore, "different consumers may react with divergent levels of involvement to various products" (Mowen & Minor, 2001, p.39.). Attitudes toward environmentally friendly products change depending on the level of consumer involvement in products. If health is the highest priority for consumers, they purchase organic foods for their nutritional value rather than for environmental concerns. However, if consumers regard environmental or ethical aspects as very important, they buy environmentally-friendly detergent even at a higher price. Fotopoulos and Krystallis (2002) surveyed Greek consumers' opinions about organic food. The overall reasons Greek consumers purchased organic food were that it was environmentally friendly, healthy, tastier, and of better quality.

Although many kinds of environmentally-friendly products are available, not all products can gain consumer favor. Environmental messages, advertising, and labels can increase consumer involvement. Several studies have been conducted to determine the effectiveness of environmental labeling (Table 6.1). Results show that consumer involvement changes depending on a product's category and information contained on the environmental label. In addition, accessibility and convenience also influence consumer involvement with products (Solomon & Rabolt, 2004; Bhate & Lawler, 1997). Consumers can only buy products that are available.

Consumers have different depths of involvement with particular products, and these depths influence their behavior. Product involvement affects relative importance of the product class and perceived difference in product attributes (Solomon & Rabolt, 2004). Consumers who purchase organic food or recycled paper may not purchase environmentally friendly clothing (EFC) because, "Apparel and fashion purchasing is generally thought of as a high-involvement activity" (Solomon & Rabolt, 2004, p.122). Product involvement, such as "shopping for children's clothing" and "purchasing of organic cotton clothing," was measured by Zaichowsky's (1994) personal involvement inventory (1994) as: Important/unimportant, boring/interesting, relevant/irrelevant, exciting/unexciting, means nothing/means a lot to me, appealing/unappealing, fascinating/mundane, worthless/valuable, not needed/ needed. Understanding parents' involvement in both children's clothing and EFC is essential to the apparel company producing or planning to produce children's EFC. This study examine whether the involvement with children clothing and the involvement with organic cotton are related to each other.

"insert Table 6.1"

Product Performance and Purchasing Behaviors of Children's Clothing

Darian (1998) found that price is the most important factor, over other factors such as quality and design, in determining parents' purchasing decisions. One reason could be that children grow quickly and parents need to replace their clothing often. However, more recent literature stated that price is not as critical a factor influencing the purchase of children's clothing (Chen et al., 2004; Kőksal, 2007). In addition, recent trends for young children's clothing have changed. Sales on infant and toddler apparel have increased over the last five years while the birth rate has decreased (Verdon, 2003). One of the reasons for this trend could be that there are fewer numbers of children in families, so their parents and grandparents spend more money on gifts (Verdon, 2003). Another reason could be that many of today's parents have their first child when they are in their mid-30's, after achieving stable careers and earning more disposable income (Prendergast & Wong, 2003). To adapt to this trend, companies for young children's clothing have diversified into two segments (Verdon, 2003). One segment sells moderately-priced clothing, and the other sells luxury or high-priced items. Parents' interest in brand name and luxury apparel is increasing, and luxury brand companies are extending their product lines into the young children's market (Corral, 1999).

Due to increased anxiety about health effects from pesticide residues and unsafe dyes on cotton fabrics, parents with young children have shown an interest in organic cotton (Nimon & Beghin, 1999) because children are more vulnerable to the potential toxins used in apparel. A recent survey by Wal-Mart found that 74% of parents who have young children are interested in organic apparel (Nolan, 2006). Another viable reason for parents' interest in organic clothing is that they want to preserve the future environment for their children. This reason is supported by the survey results of Butler and Francis (1997), who found that consumers who have children showed higher environmental concern.

Prendergast and Wong (2003) attempted to identify the behavior of parents who purchase luxury brands of infant clothing in Hong Kong. Parents said their reason for purchasing luxury brand clothing for their young children was that luxury brand clothing has better quality and design. Only a small number of respondents said they purchased luxury brands for conspicuous consumption. This result could be applied to the acceptance of EFC for young children if parents perceive environmentally friendly characteristics as synonymous with high quality.

A complex combination of factors affects consumer clothing purchasing decisions. Product quality, design, and style are important in clothing evaluation. In addition, one of the reports showed that people preferred organic cotton clothing because it maintained a better tactile sensation, which is important for young children. This factor also explained why consumers who did not have environmental concerns bought EFC.

Research Conceptual Framework

The proposed conceptual framework (Figure 6.1) was developed based on the previous studies mentioned earlier with the addition of topics to be researched in this study. Five independent variables were identified that influence the acceptance of EFC: 1) socio-demographics, 2) product involvement, 3) price premium, 4) product performance, and 5) environmental aspects. The dependent variable was the acceptance of EFC. This acceptance was measured by three factors: 1) selection of children's organic cotton clothing, 2) willingness to purchase EFC, and 3) product involvement with organic cotton. The goal of measuring willingness to purchase EFC was to understand consumers' general opinions about it. Participants were asked about their willingness to purchase and to pay more for EFC. Consumers may show an interest in EFC, but their actual selection may be different. Therefore, to gain a more accurate measurement of EFC selection, a real selection between organic cotton and non organic cotton clothing was presented to participants. Currently, most available EFC is organic cotton clothing. Measuring involvement with organic cotton allowed this study to see whether participants were interested in purchasing organic cotton clothing. To measure involvement, this study employed Zaichowsky's (1994) personal involvement inventory.

"insert Figure 6.1"

Hypotheses

Hypotheses were formed based on the review of literature. Null hypotheses were categorized by independent variables. The methods for testing the hypotheses are summarized in Table 6.2

"insert Table 6.2"

Socio-demographics

Socio-demographics were used to determine the relationship of 1) selection of organic cotton and 2) involvement with organic cotton. Participants' age, education level, employment status, and income level were included in socio-demographic variables.

H1$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of socio-demographics.

H1-1$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their age.

H1-2$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their education level.

H1-3$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their employment status.

H1-4$_0$: There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of their income level.

H2$_0$: There are no significant differences in "involvement with organic cotton" among different levels of "socio-demographic information."

H2-1$_0$: There are no significant differences in "involvement with organic cotton" among different levels of age.

H2-2$_0$: There are no significant differences in "involvement with organic cotton" among different levels of education.

H2-3$_0$: There are no significant differences in "involvement with organic cotton" among different levels of employment status.

H2-4$_0$: There are no significant differences in “involvement with organic cotton” among different levels of income.

Product Involvement

This study included: 1) items from Zaichowsky’s personal involvement inventory, 2) the frequency of shopping for children’s clothing, and 3) money expenditure on children’s clothing as a measure of product involvement because participants who have a higher interest in children’s clothing, meaning they spend more time and/or more money on it, may show a higher interest in organic cotton. This study utilized Zaichowsky’s (1994) personal involvement inventory twice. The first instance was in measuring involvement with children’s clothing (2nd independent variable), and the second was in measuring involvement with organic cotton (3rd dependent variable).

H3$_0$: There is no relationship between the personal involvement inventory with children’s clothing and the personal involvement inventory with organic cotton.

H4$_0$: There are no significant differences in “willingness to purchase EFC” between different levels of “frequency of shopping for children’s clothing.”

H5$_0$: There are no significant differences in “willingness to purchase EFC” between different levels of “money expenditure on children’s clothing.”

Price premium

The price premium factor was measured to see whether or not pricing information influenced the selection of EFC. In addition, participants were asked their reasons for selecting organic cotton clothing because price may be a deciding factor when selecting children’s clothing.

$H6_0$: There is no relationship between different price information and "selection of EFC."

Product performance

This study used the factors of design, quality, fabric, and softness to define product performance. The relationship between product performance and selection of organic cotton clothing was formulated as Hypothesis 7.

$H7_0$: There is no relationship between product performance and selection of organic cotton clothing.

Environmental variables

Environmental variables included environmental concerns, environmental attitudes, environmental knowledge, recycling behaviors, and environmental purchasing behaviors. Environmental variables were compared to involvement with organic cotton, which was measured by Zaichowsky's (1994) personal involvement inventory.

$H8_0$: There is no relationship between environmental variables and involvement with organic cotton.

Methods

The purpose of this study was to examine consumer acceptance of EFC. To collect the data of consumers' acceptance of environmentally-friendly clothing, this study chose a survey method with follow-up discussion. In addition, a buying scenario was employed to examine whether or not pricing influences consumers' actual purchasing decisions.

Questionnaire Development

This study developed an instrument suitable for quantitative analysis based on a comprehensive review. Self-administrated questionnaires were distributed with the clothing sample. The questionnaire consisted of five parts. First, socio-demographic information was obtained to determine respondents' profiles and to examine socio-demographics in relation to the selection of organic cotton clothing and involvement with organic cotton. Respondents' age, education level, employment status, and income level were obtained.

The second section of the questionnaire was related to participants' involvement with children's clothing. Respondents' clothing purchasing behavior for their children was included as items measuring product involvement. The questionnaire inquired about frequency of shopping, money expenditure on children's clothing, brand or store preference, and other important evaluation criteria. In addition, product involvement with children's clothing and organic cotton clothing was measured by Zaichowsky's (1994) personal involvement inventory.

The third part of the questionnaire was the buying scenario, which examined the influence of increased pricing on the selection of organic cotton clothing. Respondents answered these questions after they observed the clothing samples. Questions about participants' selection based on product performance, including design, quality, softness, and fabrics, were included to help determine why participants selected one clothing item over another. The scenario also included price as a possible selection criteria.

The fourth section solicited details of consumers' environmental variables (environmental concerns, knowledge, attitudes, and behaviors). Items for environmental variables were adopted from previous literature (Chan, 2001; Laroche et al., 2001; Ling-yee, 1997; Bohen, et al., 1993) with the wordings changed to fit this study. Items in "environmental concerns and attitudes" employed a five-point Likert scale with 1 being *strongly disagree* to 5 being *strongly agree*. For environmental behavior, respondents designated their frequency of actions from 1, *never* to 5, *always*. Finally, participants were asked their willingness to purchase EFC, their willingness to switch from their regular brands or stores to purchase EFC, their willingness to pay more for EFC, and their past experiences of purchasing EFC.

Before collecting data, a pretest was performed with five mothers of young children. This group interview generated preliminary impressions, ideas, and suggestions about the acceptance of EFC. The necessary corrections were made based on the opinions of the pretest participants.

Population and Sample Selection

The purpose of this study was to examine consumers' acceptance of environmentally-friendly clothing (EFC). For young children, clothing is purchased by parents, so parents who have young children from ages 0 to 4 years were selected as the targeted population. The results from this study cannot be generalized to all consumers because this study only obtained samples from residents of Oklahoma. However, it was important to identify a target group who was likely to purchase EFC. For this study, a convenient sampling method was used. The first selected groups were Mothers of Preschoolers (MOPS) in churches. A list of MOPS groups in three cities was used to contact participants. A total of eight groups gave permission to survey them. However, this study could obtain data from only five of these groups because of cancellations due to weather. The MOPS groups were located in three cities, Oklahoma City, Tulsa, and Stillwater. A second source of participants was parents whose children attend preschool programs.

The survey data gathering effort began in the middle of December, 2006 and was completed at the end of February, 2007. A surveyor visited the site to administer surveys and gave questionnaires directly to parents who were willing to participate. A total of 174 questionnaires were obtained. After eliminating unusable surveys, a total of 156 questionnaires from six sites within the three cities was used to analyze the data. Questionnaires were deemed unusable if participants did not complete selection choices or demographic information or if participants completed the beginning of the questionnaire but not the end.

Clothing Sample Selection and Buying Scenario

This study provided two sets of children's clothing as samples. Each set consisted of organic and conventional cotton clothing. Bodysuits (onesies) were selected for the sample items. Before purchasing the samples, a panel composed of university faculty was involved in refining the clothing samples to assure deviation in possible reasoning for clothing acceptance. In addition, a panel examined pricing information from online websites and brick/mortar shops to determine the average price of a similar bodysuit. After searching 35 web sites (15 organic cotton product websites and 20 conventional cotton product websites) and visiting 15 stores (in the three cities used for the survey), the price range was identified. The price of items varied depending on design and quality.

For example, if the hem was double folded, the cost was higher than for a single-folded hem. The average price of an organic cotton bodysuit with a design on the front was $16.05. The average price of a conventional bodysuit with a design on the front was $9.85. An approximately 63 % price difference existed between organic and conventional cotton clothing with similar style, quality, and functional aspects.

Initially, four organic cotton bodysuits and ten conventional cotton body suits were obtained. Two of each of these were selected as clothing samples because their colors were the same (White) and both had similar designs on the front. Also, both samples had three snaps on the bottom, a lap shoulder, and double-folded hem. (Figure 6.2) Original tags and labels were removed, and the author affixed new tags to give manipulated price information to participants. The newly designed tags also contained fabric information designating organic cotton or conventional cotton.

To understand how price influences purchasing decisions, this study conducted three versions of the buying scenario: one with a 60% higher price for organic cotton clothing, one with a 30% higher price for organic cotton clothing, and one with no price information for the control group. Consumers selected one of the two currently available children's clothing samples with differing variations in ecological and price information (Table 6.3). The two experimental variables were cotton materials information and price information. Data were collected in focus groups. Each group was randomly assigned one of the three buying scenarios.

"insert Figure 6.2"

"insert Table 6.3"

This buying scenario allowed the study to estimate the implicit consumer-perceived value of the selected children's clothing. In the survey, respondents selected one clothing item from each set and specified the reasons for their decision. Participants were grouped into those who accepted EFC and those who did not accept EFC. Additionally, from the reasons given, this study identified why consumers selected or did not select EFC based on product performances such as (1) design, (2) quality, (3) softness, and (4) fabrics. The study also identified how pricing determined the parents' selections based on their answers to these questions in the survey.

Statistical Analysis

Questionnaires were analyzed using the Microsoft Windows statistical package SPSS 14.0. First, descriptive statistics were used for recognizing the demographic information of respondents. Second, descriptive statistics were used to identify participants' behaviors. Third, influential statistics including comparisons and correlations were used to examine the relationship between independent variables and dependent variables. To compare subgroups of respondents, a Chi-square was used to analyze differences among categorical data. One-way analysis of variance (ANOVA) was used to test significance in the effect of demographic information (age, income, education, and employment status) on acceptance of EFC. Factor analysis was used for evaluating both independent variables (predictors: children's clothing involvement, product performance, environmental concerns and environmental behavior) and the dependent variable (acceptance of EFC). Multiple regression and correlations analysis were used to determine whether independent variables could predict dependent variables and whether there were positive or negative relationships among variables. In addition, a reliability test was conducted on four categories: 1) involvement in children's clothing, 2) involvement in organic cotton clothing, 3) environmental concerns, and 4) environmental behavior. Cronbach's coefficient alpha was used. The result of the reliability of these characteristics measurements were sound, with the reliability coefficient ranging from .66 to .96.

Results

The results of the analysis are presented in three sections. The first section is respondents' demographic characteristics, and the second section is the descriptive analysis of parents' purchasing behavior for children's clothing. The third section is the results of the influential analysis to test hypotheses and examination of acceptance of environmentally friendly clothing (EFC).

Respondents' Demographic Characteristics

The respondents' demographic information is summarized in Table 6.4. All respondents were female, and the age of participants ranged from 22 to 47. A majority of respondents were from 26 to 40-years-old (83.4%). More than 96% of participants were married, and 91.7% of them were Caucasian. Overall, 73.8% of respondents had a college degree or higher level of education. A majority of respondents (60.9%) were full-time homemakers, 7.7% had full-time jobs, and 28.2% had part-time jobs.

About 5% of respondents' household incomes were less than $35,000 per year, and 21.2% reported an annual household income before tax of less than $60,000. More than 40% had annual income ranges from $60,001 to $90,000, and 20.6% reported their income ranges from $90,001 to $150,000. About 13% of participants reported an annual income of more than $150,001. Almost half of the respondents had four family members in their household (48.7%) and had two children (53.8%). The youngest child in households ranged from 0 to 4 years old. The demographic information shows, respondents were middle aged, were highly educated, and had relatively high incomes.

"insert Table 6.4"

Behavioral Descriptive Analysis

Parents' behavior was analyzed in terms of purchasing of children's clothing, product involvement, organic cotton clothing selection including price information and product performance, level of environmental aspects, and willingness to purchase EFC.

Product Involvement with Children's Clothing and Organic Cotton

To understand fundamental motivations for purchasing children's EFC, the data on product involvement with respect to children's clothing were collected within three categories: 1) shopping frequency, 2) money expenditure for children's clothing, and 3) involvement inventory measurements. In addition, involvement with organic cotton was included in the acceptance of EFC category.

Questions regarding shopping frequency showed that only 4.5% shopped once a week, and 29.5% shopped twice a month. About 33% of mothers shopped once every three to four months, and 22.4% shopped once every 5 to 6 months. Approximately 23%

of participants reported spending $10-$19, 35% reported $20 - $39, and 19% reported $40-$59 for each shopping instance (Table 6.5). The mean of involvement with children's clothing is presented in Table 6.6, and the mean of involvement with organic cotton is presented in Table 6.7.

"insert Table 6.5"

"insert Table 6.6"

"insert Table 6.7"

<u>Clothing Selection</u>

This study used buying scenarios to examine whether or not price influenced consumers' actual purchasing decisions. Additionally, product performances such as design, quality, softness, and fabric were analyzed to examine what other factors, besides price, parents considered when purchasing children's clothing. Overall, participants selected more non organic cotton clothing (52.6%) rather than organic cotton clothing. When participants selected organic cotton clothing, it was most often because of its softness (59.5%) and design (18.9%). Participants selected non organic clothing because of its design (54.9%) and price (23.2%).

"insert Table 6.8"

"insert Table 6.9"

Environmental Aspects

Questions related to environmental concerns, environmental attitudes, and environmental knowledge used a five-point Likert scale from 1 being *strongly disagree* to 5 being *strongly agree.* Recycling behavior and environmental purchasing behavior were measured with a five-point Likert scale from 1 being *never* to 5 being *always*.

"insert Table 6.10"

"insert Table 6.11"

Factor analysis was used to determine the relationships among environmental variables. In addition, factor analysis was used to eliminate any variables that did not correlate with any other variables. Based on factor loadings, one variable was eliminated from the environmental concern category, and four factors were generated. These generated factors were used in regression analysis. Ten items in environmental attitudes, concerns, and behaviors and eight items in recycling and environmental purchasing behavior were tested for factor analysis. The analysis used the Principal Factor method for extraction with Varimax rotation, and the Eigenvalues were examined to determine the number of factors. On the basis of the size of loading, five factors were created (Table 6.12). The items that had greater than .40 in absolute value were grouped together. As a result, two items were removed (items 5 and10).

"insert Table 6.12"

The first factor was generated to measure environmental attitudes and had three items. The second factor was related to environmental concerns and is included two times.

Three items were included for measuring environmental knowledge. The fourth factor, recycling behavior, and fifth factor, environmental purchasing behavior, were generated. These generated factors were used in multiple regression analysis.

Willingness to Purchase EFC

To examine the willingness of consumers to purchase EFC, participants were asked about previous purchasing of EFC. Only 9% of consumers had experience purchasing EFC. All of those had purchased organic cotton clothing, and some of them had purchased organic wool clothing or recycled polyester clothing. Their most important reason for purchasing was the quality and design of the products. Respondents' most frequent reasons for not purchasing EFC were it was not available (22.8%) and was expensive (20.2%). However, more than half of participants were willing to purchase EFC in the future, and their reasons were for the environment (14.3%) or for quality (13.1%). They also indicated wanting to purchase either organic or hemp products (13.1%). More than half of participants who were willing to purchase EFC were willing to switch from their favorite brands to purchase EFC, but only 35% of them, which was 17.8% of total participants, were willing to pay more for EFC. Even participants who were willing to pay more were not willing to pay more than 10% (66.7%). This result indicates that price is the most critical factor for consumers' in selecting or not selecting children's clothing.

"insert Table 6.13"

Acceptance of Environmentally Friendly Clothing(EFC)

To test Hypothesis 1, "There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of socio-demographics," this study used t-test for comparisons. The two groups (select EFC or non-EFC) were compared in terms of age, education, income, and employment status. None of these variables showed significant differences. [Age (t=-1.05, p=.29), Education (t=.79, p=.43), Income (t=-.36, p=.72), Employment status (F=.20, p=.66)] Therefore, Hypothesis 1 was not rejected.

Hypothesis 2, "There are no significant differences in 'the involvement with organic cotton' between different levels of 'socio-demographic information,'" was tested with One-way analysis of variable (ANOVA) to compare means of the acceptance of EFC for levels of demographic information. Between socio-demographic items, (a) age, (F=1.69 p=.14), (b) education (F=2.47, p=.09), and (c) employment status (F=2.39, p=.07) significant differences were not shown. However, the acceptance of EFC was significantly different between (d) income level groups (Table 5.11). Therefore, Hypothesis 2 was partially rejected.

Income levels were divided into five groups based on data by the United State Census Bureau (2006). According to the US Census Bureau (2006), the median household income in 2005 was $46,326, the lowest 40% of the population had a household income of up to $35,999, the lower median population had a household income from $36,001 to $57,657, and the higher median group had a household income from $57,658 to $91,704. The top 5 percent of the population had an annual income of more than $157,176. Therefore, for this study, the lowest income level group set at up to

$35,000, the lower median income group ranged from $35,001 to $60,000, the higher median income group ranged from $60,001 to $90,000, the high income group ranged from $90,001 to $150,000, and the highest income group more than $150,001. Results showed that the acceptance of EFC changed based on levels of income.

Follow-up tests were conducted to evaluate pairwise differences among the means. This study used Fisher's Least Significant Difference (LSD) as the post hoc test because LSD tests are appropriate for different group sizes. A significant difference was found in the means between the groups that had lower median income and high income, higher median income and high income, and high income and the highest income. However, the result was not congruent with previous investigations that showed consumers who have higher income also haves higher interest in green products (Ling-yee, 1997). Higher income may be related to the higher acceptance of other environmentally – friendly products (i.e. food), but was not shown to be related to higher acceptance of EFC.

"insert Table 6.14"

The regression analysis was used to test Hypothesis 3, "There is no relationship between involvement with children's clothing and involvement with organic cotton." The result of the analysis indicated that involvement in children's clothing was not related to the acceptance of EFC. (R^2 = .02, adjusted R^2 = .01, F (1,146) = 2.82, p=.10). Hypothesis 3 was not rejected.

"insert Table 6.15"

Hypotheses 4 and 5 dealt with consumers' willingness to purchase EFC: Hypothesis 4, "There are no significant differences in 'willingness to purchase EFC' between different levels of 'frequency of shopping for children clothing,'" Hypothesis 5, "There are no significant differences in 'willingness to purchase EFC' between different levels of 'money expenditure on children's clothing.'" A t-test was used to compare whether there were differences between the two groups of respondents who are willing to purchase EFC and those who are not willing to purchase EFC or responded "do not know" for their willingness to purchase EFC. The study questionnaire inquired about shopping frequency and money expenditure for children's clothing. There were no significant differences between the two groups of respondents in mean of the frequency of shopping ($t=.66$, $p=.51$) or money expenditure ($t=.59$, $p=.55$) for children's clothing. Hypotheses 4 and 5 were not rejected. This suggested that the frequency of shopping for children's clothing and money expenditure for children's clothing are not related to the acceptance of EFC.

A cross tabulation analysis and chi-square were conducted to test Hypothesis 6, "There is no relationship between different price information and 'selection of EFC.'" The two variables were (1) price differences (IV) with three levels (60% higher, 30% higher, and no price information) and (2) fabric information (DV) with two levels (organic cotton and non organic cotton) whose purpose was to determine whether and to what degree price differences influenced the selection of organic cotton and conventional cotton clothing. A Pearson chi-square was used to see how the two variables were interrelated.

Price and organic cotton information was found to be significantly related

(Person $\chi^2 = 5.79$, $p<.05$). Table 6.8 shows that when no price information was given, the consumers selected more organic cotton clothing. Therefore, Hypothesis 6 was rejected. Because this analysis had more than two degree of freedom, follow-up tests were conducted to examine particular sub-hypotheses (Table 6.9). The Home's sequential Bonferroni method was used to control Type I error at the .05 level across all three comparisons. The results from follow-up pairwise comparisons showed that there were significant differences between participants who had 60% higher price information and those who had no price information.

"insert Table 6.16"

"insert Table 6.17"

Price has been shown to be a more critical issue when consumers are making purchasing decisions for apparel products as opposed to other products. There were significant differences in clothing selection when consumers were given a 60% higher price for organic cotton clothing than when no price information was given. This result corresponded to the experiment for eco-labeled pencils by Anderson et al. (2005).

Hypothesis 7, "There is no relationship between product performance and selection of organic cotton clothing," was tested by a cross tabulation analysis and chi-square to describe what characteristics consumers consider when they purchase children's clothing. The two variables were product characteristics with five levels and selection of EFC with two levels (Table 5.10). Pearson Chi-Square tests were used to determine whether the two consumer groups, those who select organic cotton clothing and those who select non organic cotton clothing showed significant differences in what they considered important product characteristics (Pearson χ^2 (4, N=156) =66.69, p=.00). Consumers in this study selected organic cotton clothing because of its softness (59.5%) but selected non organic cotton clothing because of its design (54.9%) (Table 6.9). Therefore, Hypothesis 7 was rejected.

Multiple regression analysis was used to test Hypothesis 8, "There is no relationship between environmental variables and involvement with organic cotton." Five factors that were generated from factor analysis earlier in this study were used for multiple regression analysis. The results showed that the relationship between environmental variables and the acceptance of EFC was significant (R^2 = .35, adjusted R^2 = .32, F (5, 140) = 14.86, p=.00). Therefore, this study rejected Hypothesis 8. All β values are positive, and this means that environmental aspects have a positive influence on the acceptance of EFC, especially, environmental knowledge (β= .34), recycling behaviors (β= .21), and environmental purchasing behaviors (β= .29).

"insert Table 6.18"

This study has confirmed previous findings that environmental variables are related to purchasing decisions for environmentally friendly products (Lannuzzi & Haviland, 2006; Diamantopoulos, et al., 2003; Zimmer et al., 1994). These results indicated that an individual's environmental knowledge and behavior are greater determinants of his or her acceptance of EFC than the individual's socio-demographic level or involvement with children's clothing.

Conclusions

In response to increasing consumer concerns about environmental problems, some apparel companies have been producing environmentally-friendly clothing (EFC). Some of these companies try to produce EFC to enhance their image as being socially responsible; and generally, these companies have carved a niche for themselves within the industry. However, without understanding consumers' opinions and perceptions of EFC, gaining a competitive advantage is difficult for these companies. This research contributed to previous studies of consumer environmental behavior by examining the determinants of parents' acceptance of EFC. The findings from hypotheses testing are summarized in Table 6.19.

"insert Table 6.19"

The knowledge of consumers' acceptance of EFC for the specified target group (in this study, mothers) is important for the apparel company to develop a marketing strategy. The most important finding from this study is that consumers' environmental knowledge and environmental behaviors influence the acceptance of EFC over their socio-demographics or their interests (involvement with) in children clothing. Also, price is the most critical factor in determining when consumers actually select the apparel products. Market research by team members for this study found that the price difference between organic and conventional cotton clothing is approximately 60% when the clothing has a similar style, quality, and functional aspects. However, the results showed that consumers are less likely purchase EFC when is has 60% higher price, so currently available organic cotton clothing is considered expensive to consumers. In addition, consumers who have higher environmental knowledge and behavior are more likely to be targeted as EFC consumers. Therefore, one of the suggested marketing strategies is to provide environmental information to consumers.

As Meyer (2001) mentioned, higher price, little choice, aesthetic, lack of information, and uncertainty about actual benefits to the environment are big challenges for the apparel industry in realizing an environmentally-friendly strategy. Respondents in this study also indicated that that they could not see any difference between EFC and non-EFC. These comments indicate that respondents did not regard the higher price of EFC as equivalent to the benefits solely based on environmental factors and without other advantages, such as design or quality.

From the follow up discussions, this study found that some parents had never heard of organic cotton clothing before, indicating that lack of information could be one of the reasons that EFC has not become mainstream. Some respondents even stated that while organic food may be beneficial for their health, there was no direct benefit to them in purchasing EFC. This could be the reason that consumers were not willing to spend more money for EFC. Research on marketing strategies for EFC should be further explored. This study only tested one kind of children's clothing item, and future studies are necessary to broaden the scope of EFC market research. Continuous reassessment of the acceptance of environmentally-friendly children's clothing is essential for the apparel industry to gain competitive advantage during this time of growing environmentally-friendly trends.

References

Anderson, R.C., Laband, D.N., Hansen, E.N., & Knowles, C.D. (2005). Price premiums in the mist. *Forest Products Journal, 55*(6), 19-22.

Berry, D. (2005). Lab talk: Many reasons to go organic. *Dairy Foods, 106*(10), 60

Bhate, S. & Lawler, K. (1997). Environmentally friendly products: Factors that influence their adoption. *Technovation, 17*(8), 457-465.

Bjørner, T.B., Hansen, L.G., & Russell, C.S. (2004). Environmental labeling and consumers' choice – an empirical analysis of the effect of the Nordic Swan. *Journal of Environmental Economic and Management, 47*, 411-434.

Bohlen, G., Schlegelmilch, B., & Diamantopoulos, A. (1993). Measuring ecological concern: A multi-construct perspective. *Journal of Marketing Management, 9*, 415-430

Butler, S.M., & Francis, S. (1997). The effects of environmental attitudes on apparel purchasing behavior. *Clothing and Textile Research Journal, 15(2)*, 76-85.

Chan, R.Y.K. (2001). Determinants of Chinese consumers' green purchase behavior. *Psychology & Marketing, 18*(4), 389-413.

Chen, X., Au, W.M., & Li,K. (2004). Consumption of children's wear in a big city in central China: Zhengzhou. *Journal of Marketing Management, 8(*2), 154-165.

Corral, C.B. (1999). Brand name clothing, baby superstores are among the recent retail trends aimed at babies. *Discount Store News*, 38.

Darian, J.C. (1998). Parent-child decision making in children's clothing stores. *International Journal of Retail & Distribution Management, 26*(11), 421-428.

Diamantopoulos, A., Schlegelmilch, B. B., Sinkovics, R.R., & Bohlen, G.M. (2003). Can socio-demographic still play a role in profiling green consumer? A review of the evidence and an empirical investigation. *Journal of Business Research, 56*, 465-480.

D'Souza, C. (2004). Ecolabel programmes: A stakeholder (consumer) perspective. *Corporate Communications, 9*(3), 179-188.

Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention and behavior. Reading, MA: Addison-Wesley.

Fotopoulos, C. & Krystallis, A. (2002). Purchasing motives and profile of the Greek organic consumer: A countrywide survey. *British Food Journal, 104*, (9), 730-765

Fraj, E. & Martinez, E. (2006). Environmental values and lifestyle as determining factors of ecological consumer behavior: an empirical analysis. *Journal of Consumer Marketing, 23*(3), 133-144.

Gardyn, R. (2003). Eco-friend or foe? *American Demographics, 25*(8), 12-13.

Jones, P., Clarke-Hill, C., Shears, P. & Hillier, D. (2001). Retailing organic foods. *British Food Journal, 103*(5), 358-365.

Kim, H., & Damhorst, M.R. (1998). Environmental concern and apparel consumption. *Clothing and Textiles Research Journal, 16*(3), 126-133.

Köksal, M. H. (2007). Consumer behavior and preference regarding children's clothing in Turkey. *Journal of Fashion Marketing and Management, 11*(1), 69-81.

Lannuzzi, A. & Haviland, R. T. (2006). Design for the environment at Johnson & Johnson: A product design process. *Environmental Quality Management*, 43-50.

Laroche, M., Bergeron, J., &Barbaro-Forleo, G. (2001). Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing, 18*(6), 502-520.

Ling-yee, L. (1997). Effect of collectivist orientation and ecological attitude in actual environmental commitment: The moderating role of consumer demographics and product involvement. *Journal of International Consumer Marketing, 9*(4), 31-53.

Meyer, A. (2001). What's in it for the customers? Successfully marketing green clothes. *Business Strategy and the Environment, 10*(5), 317-330.

Mowen, J., C., & Minor, M. S. (2001). *Consumer Behavior: A Framework.* Prentice Hall, New Jersey.

Murphy, R., M. (2004). Truth or scare. *American Demographics, 26*(2), 26-32.

Nimon, W., & Beghin, J. (1999). Are eco-labels valuable? Evidence from the apparel industry. *American Journal of Agricultural Economics, 81*(5), 801-811.

Nolan, K. (2006). Wal-Mart first mass retailer to offer organic clothing. *DNR Retailing Today, 45*(9), 20.

Prendergast, G. & Wong, C. (2003). Parental influence on the purchase of luxury brands of infant apparel: An exploratory study in Hong Kong. *Journal of Consumer Marketing, 20*(2), 157-169.

Solomon, M.R. & Rabolt, N., J. (2004). *Consumer Behavior in Fashion*. Prentice Hall, New Jersey

United States Census Bureau. (2006). Current Population Survey. Retrieved March 14, 2007 from http://www.census.gov/hhes/www/income/income05.html

Verdon, J. (October, 4, 2003). Sales of baby clothing increases over 20 percent in 2002. *Record, The (Hackensack, NJ)*.

Zaichkowsky, J.L. (1994). The personal involvement inventory: reduction, revision, and application to advertising. *Journal of Advertising, 23*(4), 59-70.

Zimmer, M. R., Stafford, T.F., & Stafford, M.R. (1994). Green issues: Dimensions of environmental concern. *Journal of Business Research, 30*(1) 63-74

Table 6.1. The Effect of Environmental Labels and Product Characteristics

Product	Environmental characteristic	Did label have an effect?
Detergent	Content of phosphate	Yes
Canned seafood and substitute meat products	Dolphin-safe label	Yes
Toilet paper	Unbleached	No
	Recycled	Yes
Apparels	Environmentally-friendly dyes	No
	Organic cotton	Yes
Electricity	Certified green electricity	Yes

(This table is adapted from Bjørner, Hansen, & Russell, 2004)

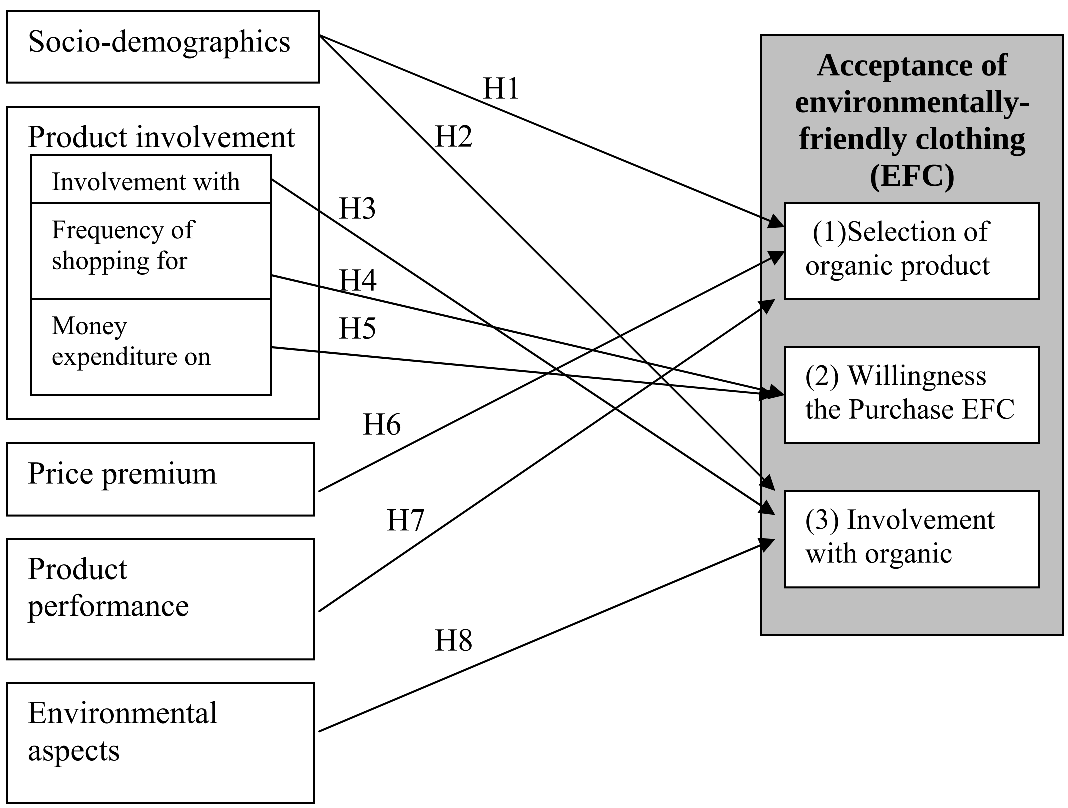

Figure 6.1. Conceptual Framework

Table 6.2. The Methods for Testing Hypothesis

Analysis Method	Hypothesis
Chi-square analysis	H6, H7
t-test or ANOVA	H1, H4, H5
Multiple regression analysis	H2, H3, H8,

Figure 6.2 Bodysuit Samples (Left: organic cotton clothing/ Right: non organic cotton clothing)

Table 6.3. Consumer Acceptance of EFC and Price Difference

Sample set	60% price difference		30% price difference		No price information	
Material Type	Organic cotton	Conventional cotton	Organic cotton	Conventional cotton	Organic cotton	Conventional Cotton

Table 6.4. Demographic Characteristics of Participants (N=156)

Variable	Frequency	Percent[a]
Gender		
Female	156	100.0
Age		
22-25	4	2.6
26-30	38	24.4
31-35	71	45.5
36-40	21	13.5
41-45	15	9.6
46 and over	7	4.5
Education		
Less than high school	0	0.0
Some high school	0	0.0
High school graduate	4	2.6
Some technical school	1	0.6
Technical school graduate	0	0.0
Some college	34	21.8
College graduate	77	49.4
Post graduate or professional degree	38	24.4
Other	2	1.3
Employment Status		
Full-time	12	7.7
Part-time	44	28.2
Unemployed	95	60.9
Other	5	3.2
Income		
Less than $20,000	3	1.9
$20,001-$35,000	5	3.2
$35,001-$50,000	16	10.3
$50,001-$60,000	17	10.9
$60,001-$75,000	29	18.6
$75,001-$90,000	34	21.8
$90,001-$100,000	11	7.1
$100,001-$150,000	21	13.5
$150,001 or more	20	12.8

[a] Total percent may not be equal to 100 due to non-responses

Table 6.5. Participants' Children Clothing Purchasing Behavior

Variable	Frequency	Percent[a]
Frequency of shopping occurrence		
Once a week	7	4.5
Twice a month	46	29.5
Once a month	52	33.3
Once every 3-4 months	35	22.4
Once every 5-6 months	11	7.1
Once or twice a year	5	3.2
How much spent at each shopping		
Less than $10	6	3.8
$10- $19	36	23.1
$20- $39	54	34.6
$40- $59	30	19.2
$60- $79	19	12.2
$80- $99	8	5.1
$100 - $ 199	3	1.9

Table 6.6. Involvement with Children's Clothing

Items		Mean	SD
5= Important	1 = Unimportant	4.15	0.878
5= Interesting	1= Boring	3.90	0.893
5= Exciting	1= Unexciting	3.90	0.941
5= Means a lot to me	1= Means nothing	3.69	0.982
5= Appealing	1= Unappealing	3.82	0.905
5= Fascinating	1= Mundane	4.12	0.837
5= Valuable	1= Worthless	3.38	0.971
5= Involving	1= Uninvolving	3.92	0.913
5= Needed	1= Not needed	4.61	0.824

Table 6.7. Involvement with Organic Cotton

Items		Mean	SD
5= Important	1 = Unimportant	2.61	1.197
5= Interesting	1= Boring	3.16	1.167
5= Exciting	1= Unexciting	2.80	1.138
5= Means a lot to me	1= Means nothing	2.66	1.137
5= Appealing	1= Unappealing	2.44	1.105
5= Fascinating	1= Mundane	2.91	1.181
5= Valuable	1= Worthless	2.72	1.081
5= Involving	1= Uninvolving	2.94	1.113
5= Needed	1= Not needed	2.78	1.263

Table 6.8. Clothing Selection

Variable	Frequency	Percent[a]
Overall selection of organic or conventional cotton clothing		
Organic cotton clothing	74	47.4
Conventional cotton clothing	82	52.6
The reasons for selecting organic clothing (N=74)		
Design	14	18.9
Quality	7	9.5
Fabric	9	12.2
Softness	44	59.5
Price	0	0.0
The reasons for selecting non organic clothing (N=82)		
Design	45	54.9
Quality	7	8.5
Fabric	6	7.3
Softness	5	6.1
Price	19	23.2

Table 6.9.Environmental Concerns, Attitudes, and Knowledge

Items	Mean	SD
Much of the food I eat is contaminated with pesticides.	3.13	.98
Many products that are made from cotton treated with pesticide may contain pesticide residues after producing into fabric	3.29	.75
I think that the government should do more to help control pollution of the environment.	4.02	.92
I think some industries are causing pollution.	4.20	.80
In our country, we have so much electricity that we do not have to worry about conservation.	2.25	1.00
Recycling is important to save natural resources.	4.19	.83
Recycling will reduce pollution.	3.94	.96
Textile dyeing releases chemicals and therefore pollutes water.	3.57	.84
Plastic bags take hundreds of years to decompose, thus they cause serious pollution	3.84	.79
I always read products' labeling and consider the environmental impact when making my selection.	2.33	.84

Table 6.10. Environmental Behavior

Items	Mean	SD
When I have a choice, I purchase organically grown fruit and vegetables	2.64	1.00
I recycle newspapers	2.88	1.56
I recycle glass	2.73	1.57
I recycle plastics	2.85	1.58
I recycle cans	2.96	1.52
I do not buy from companies that are not environmentally responsible	2.34	.93
When I have a choice, I purchase environmentally friendly products	2.98	.92
When I have a choice, I purchase recycled paper products	2.92	.94

Table 6.11. Factor Loadings for the Environmental Aspects

Factor	Factor loading
Environmental concerns	
Many products that are made from cotton treated with pesticide may contain pesticide residues after producing into fabric	.97
Much of the food I eat is contaminated with pesticides	.49
Eigenvalues 3.29	
% of the variance 25.27	
Environmental attitudes	
Recycling is important to save nature	.87
Recycling will reduce pollution.	.73
I think some industries are causing pollution	.48
Eigenvalues 1.51	
% of the variance 18.16	
Environmental knowledge	
Plastic bags take hundreds of years to decompose and cause serious pollution	.69
Textile dyeing releases chemicals and therefore pollutes water	.65
I think that the government should do more to help control pollution of the environment	.44
Eigenvalues 1.18	
% of the variance 16.56	
Recycling behavior	
I recycle glass	.96
I recycle plastics	.96
I recycle cans	.95
I recycle newspapers	.87
Eigenvalues 3.90	
% of the variance 45.28	
Environmental purchasing behavior	
When I have a choice, I purchase environmentally-friendly products	.89
When I have a choice, I purchase organically grown fruit and vegetables	.75
When I have a choice, I purchase recycled paper products	.65
I do not buy from companies that are not environmentally responsible	.53
Eigenvalues 1.82	
% of the variance 26.20	

Table 6.12. EFC Purchasing Behavior

Variable	Frequency	Percent[a]
Purchased EFC before		
Yes	14	9.0
No	104	66.7
Don't know	38	24.4
Type of items purchased		
Organic cotton clothing	14	77.8
Organic hemp clothing	0	0.0
Organic wool clothing	2	11.1
Recycled polyester	2	11.1
Other		
Reasons for purchasing EFC		
Quality	8	50.0
Design and color	6	37.5
Health issues		
Status		
Environmental protection	2	12.5
Other		
Reasons for NOT purchasing EFC		
Expensive	23	20.2
Not available	26	22.8
No difference between organic and non organic	7	6.1
Do not like design and color	3	2.6
Poor quality	1	0.9
Don't know	54	47.4
Willingness to purchase EFC		
Yes	84	53.8
No	16	10.3
Don't know	56	35.9
What kind of EFC (open ended question) (N=84)		
Anything available	25	29.8
Children's clothing	3	3.6
If quality is good	2	2.4
If quality is good and price is not expensive	4	4.8
Organic cotton or hemp products	11	13.1
Underwear (clothing near skin)	14	16.7
Don't know	25	29.8

Reasons for purchasing EFC		
For environment	12	14.3
For children's health	7	8.3
Quality	11	13.1
For fun (Want to try)	9	10.7
Don't know	45	53.6
Willingness to switch favorite brands to purchase EFC (N=84)		
Yes	43	51.2
No	9	10.7
Don't know	32	38.1
Willingness to pay more for EFC		
Yes	27	35.1
No	26	33.8
Don't know	24	31.2
How mucc more willing to pay more (N=27)		
Up to 5%	4	14.8
6% - 10%	14	51.9
11% - 15%	4	14.8
16% - 20%	1	3.7
21% - 25%	1	3.7
26% - 30%	3	11.1
31% or more	0	0.0
Reasons for not unwilling to purchase EFC		
Expensive	5	31.2
Not necessary (Not important)	4	25.0
Not available	4	25.0
Don't know	3	18.8

Table 6.13. ANOVA for Effects of Income on the Acceptance of EFC

Income Level	N	Mean	LSD	F	p
Low income (L)	10	23.00		3.34	.012
Lower median income (LM)	31	28.32	1, 2		
Higher median income (HM)	59	25.54	1		
High income (H)	30	20.47	2, 3		
The highest income (HG)	20	26.15	3		
Overall	148	25.04			

Table 6.14. Regressions Analysis of the Influence of Involvement with Children's Clothing on the Acceptance of EFC

	b	t	p
Constant	17.53	3.87	.00
Involvement of children clothing	.14	1.68	.10
R^2	.02	F (1,146)= 2.83, p=.10	
Adjusted R^2	.01		

Table 6.15. Cross Tabulation for Price Information

	Price (IV)			
Selection of EFC (DV)	60 % higher	30% higher	No price info	Total
Organic cotton	22 (39.3%)	23(43.4%)	29 (61.7%)	84
Conventional cotton	34 (60.7%)	30 (56.6%)	18 (38.3%)	83
Total	56	53	47	

Table 6.16. Follow-up Test for Price Information

Comparison	Pearson χ^2	P value
60% vs. 30%	.190	.663
30% vs. No price	3.344	.067
60% vs. No price	5.137*	.023*

Table 6.17. The Reason for Selecting Organic or Non Organic Clothing

	Product characteristics (IV)					Total
Selection of EFC (DV)	Design	Quality	Fabric	Softness	Price	
Organic cotton	14 (18.9%)	7 (9.5%)	9 (12.2%)	44 (59.5%)	0 (0%)	74
Conventional cotton	45 (54.9%)	7 (8.5%)	6 (7.3%)	5 (6.1%)	19 (23.2%)	82
Total	59	14	15	49	19	156

Table 6.18. Regressions Analysis of the Influence of Environmental Factors on the Acceptance of EFC

Environmental **a**spects	b	t	p
Constant	-10.62	-2.19	.03
Environmental Attitudes (EA)	.02	.28	.77
Environmental Concerns (EC)	.07	.87	.38
Environmental Knowledge (EK)	.34	4.44	.00
Recycling Behavior (RE)	.21	2.80	.01
Environmental Purchasing Behavior (EBH)	.29	4.15	.00
R^2	.35	F (5,140)= 14.86, p=.00	
Adjusted R^2	.32		

Table 6.19. Summary of Hypothesis Testing.

	Hypothesis	Rejected (R)/ Not rejected (N)	Conclusions
1	There are no significant differences between the two consumer groups (select EFC or select non-EFC) in terms of socio-demographic information.	N	Two groups (select EFC or not select EFC) were not different in terms of age, education, income, and employment status
2	There are no significant differences in “the acceptance of EFC” among different levels of “socio-demographic information”.	Partially R	Different income levels showed significant differences in the acceptance of EFC.
3	Involvement with children’s clothing is not related to the acceptance of EFC.	N	Involvement with children’s clothing is not related to the acceptance of EFC.
4	There are no significant differences in “willingness to purchase EFC” among different levels of “frequency of shopping for children clothing”	N	Two groups (will and not will purchase EFC) were not different in terms of the frequency of shopping for children clothing.
5	There are no significant differences in “willingness to purchase EFC” among different levels of “money expenditure for children clothing”.	N	Two groups (will and not will purchase EFC) were not different in terms of money expenditure for children’s clothing
6	Different price information is not related to the selection of EFC.	R	When organic cotton clothing had higher price, price was the most influential factor.
7	Product performance is not the reason for selecting non-EFC.	R	Participants selected children’s clothing because of its performance.
8	Environmental attitudes, concerns, knowledge, and behavior are not related to the acceptance of EFC.	R	Environmental attitudes, concerns, knowledge, and behavior were related to the acceptance of EFC.

CHAPTER VII

CONCLUSION

This research includes the following studies (1) development of C2CAD model; (2) assessment of the price of organic and non organic cotton yarns; (3) assessment of the colorfastness of selected natural and environmentally friendly and non-toxic dyes; (4) development of children's wear sweater designs; (5) production of prototype sweaters; (6) assessment of consumer acceptance of organic cotton children's clothing.

Summary of Findings

The C2CAD model was developed by integrating McDonough and Braungart's (2002) "cradle to cradle" model into existing apparel design and production models (LaBat and Sokoloskwi, 1999; May-Plumlee and Little, 1998). The C2CAD model has four main steps: 1) problem definition and research, 2) sample making, 3) solution development and collaboration, and 4) production. The C2CAD model was implemented into knitwear design and production.

In Step 1 of C2CAD, problem definition and research, this study identified current consumer needs that the model could address: 1) concerns about children's health from unsafe chemicals in clothing and 2) increased family interest in infant and toddler apparel.

Step 2, sample making, includes "material selection and testing" and "cost and design evaluation." This project used 100% organic cotton fibers grown without harmful chemicals, making the whole knitwear product a biological nutrient. Eight different colors were incorporated in the design utilizing five natural dyes and three synthetic dyes. The five natural dyes were indigo (light blue), brazilwood (pink), logwood (brown), weld (light yellow), and fustic (dark green). The only mordant used to help fix natural dyes on the yarns was salt (NaCl). Because of the unavailability of chemical information on synthetic dyes, evaluation of the three synthetic dyes was not possible without collaboration (Step 3) to share knowledge and resources. By collaborating with partners, including Dr. Lauren Heine of Green Blue Institute for this project, it was possible to evaluate the three synthetic dyes to make sure they were categorized as "green."

For cost and design evaluation, this study evaluated the dyeing performance of organic yarn to confirm whether organic cotton yarn can be salable and producible as compared to traditional cotton yarns and fabrics. Both types of yarns were dyed and tested. Four tests – breaking load, elongation, pilling, abrasion resistance, and color fastness –were conducted on "biological nutrient" yarns and knit fabrics. The results of t-test analysis showed that significant differences existed between the two types of yarns except in color fastness evaluation, specifically, color change from laundering. Results showed that after laundering, organic cotton knit fabric has significantly less color change (better color fastness) than traditional cotton knit fabric. For colorfastness after laundering (AATCC 61), all fastness ratings are 3 or higher for organic or traditional cotton fabrics. This indicates that the natural dyes and safe synthetic dyes used in this project can deliver a good dyeing quality. Therefore, this study concluded that the mechanical properties of organic cotton yarns and fabrics are acceptable for or exceed the expectations for the target market.

In cost analysis, one notable fact was identified. The actual purchasing price for organic cotton yarns was cheaper than traditional cotton yarns because the company selling organic cotton yarns had a shorter supply chain. This finding suggests that sustainable production could create economical benefits by developing an appropriate supply chain. In contrast, the implementation of the material assessment protocol in the "cradle to cradle" model (McDonough et al., 2003) incurs a high cost for chemical toxicity research and new material development. Like the "cradle to cradle" model and "intelligent materials pooling" (Braungart, 2002), the C2CAD model emphasizes the importance of industrial collaboration and knowledge sharing (step 3 of C2CAD). Therefore, this short term cost in material research will eventually turn into long term savings in many aspects, such as pollution treatment and material cost.

Step 3 of C2CAD is solution development and collaboration. In current industrial divisions, most apparel manufacturers do not produce the textile fabrics, dyes, or other apparel materials. As described earlier, this study required collaboration to analyze synthetic dyes, moving it through Step 2 and into Step 3.

The last step, Step 4 in C2CAD, is production. With an international collaboration similar to current apparel industry practices, "Four-season sustainability" children's knitwear was produced with an acceptable manufacturing cost, and the products have good mechanical and color fastness performance.

Economical benefit is one of the key components in sustainable development. In addition to the need for developing a guideline for apparel designers, there is a need for understanding of consumers' acceptance and preference of environmentally friendly clothing, or EFC, to achieve a favorable evaluation in the marketplace. Therefore, it is necessary to explore consumers' acceptance of environmentally friendly children's clothing. Investigation of consumers' opinions was carried out in this study.

The subjects in this study were a group of mothers who have young children ages 0-4 years. The survey was conducted with focus groups of 5-15 people in Oklahoma City, Tulsa, and Stillwater. Usable data were collected from 156 respondents. About 60% of respondents were full-time homemakers, and about 74% of them had a college degree. Approximately 95.5% of them were married and 92% of them were Caucasian. The findings from the survey indicated that parents (mothers) are willing to purchase environmentally friendly clothing (EFC), but only a few of the respondents (9%) had actually purchased EFC previously. The majority of respondents who had not purchased EFC before mentioned that they did not notice the existence of EFC or that the EFC was not available to purchase.

The acceptance of EFC was measured by the actual selection of organic cotton clothing, the willingness to purchase EFC, and the consumer's involvement in organic cotton clothing. The influential factors for purchasing decisions are environmental factors: environmental concerns, environmental attitudes, environmental knowledge, recycling behavior, and environmental purchasing behavior. A higher presence of environmental factors was related to higher acceptance of EFC. However, the acceptance of EFC was not related to product involvement, which was measured by Zaichowsky's (1994) personal involvement inventory, respondents' shopping frequency, and money expended on children's clothing. No significant differences emerged in the acceptance of

EFC in terms of socio-demographic variables (age, education, and employment status) except for the income variable. Unlike in previous studies (Ling-yee, 1997), higher income was not related to higher acceptance of EFC.

Product characteristics, design, quality and softness, and most importantly, price, were related to the actual selection of organic cotton clothing. The first reason for selecting organic cotton clothing was softness (60%), and respondents mentioned directly that organic cotton was softer. Product design was an important aspect for selection of both organic (19%) and non organic (55%) cotton clothing. More than half of the respondents were willing to purchase EFC when the price was reasonable and designs were acceptable. However, their willingness to purchase EFC was related to concerns for their children's health rather than for protecting the environment. Additionally, though more than half of the respondents were willing to purchase EFC, they were not willing to pay more. This information lends further support to results concluding that consumers are most sensitive to price for apparel products. Although many respondents mentioned that organic cotton was softer and this was one of their reasons for selecting it, when they had price information, the actual selection decreased. In conclusion, respondents' purchasing decisions for children clothing were associated with price and with design rather than stated environmental benefits. This result indicates that clothing purchasing decisions are made from a combination of design, softness (quality), and price. Environmental aspects did not influence the selection of organic cotton clothing. Therefore, to effectively market organic cotton clothing, it should possess benefits for consumers, such as superior quality, design, and/or price, beyond just the environmental aspects.

Respondents in this study reported relatively higher than average income, but they were statistically sensitive to the price of children's clothing. Price was the respondents' second reason for not purchasing EFC followed by unavailability. Also, buying scenarios with different price information revealed that consumers selected more organic cotton clothing when no price difference existed than when organic cotton clothing was priced 60% higher than traditional cotton clothing. Among respondents who showed their willingness to purchase EFC, most of them do not want to pay more (33.8%) or are not sure (31.2%). Market research by team members for this study found that, on average, organic cotton clothing is priced approximately 60% higher than conventional cotton clothing when they have a similar style, quality and functional aspects. Therefore, currently available organic cotton clothing is considered too expensive to most consumers.

Implications of the Study

Annually, 4.5 million tons of clothing and footwear are produced in the U.S., and only 1.25 million tons of post-consumer textiles are recovered for future use (U.S. Environmental Protection Agency, 1997). In many cases, apparel reuse and recycle means "down-cycle." In other words, the recycled materials and products have a lower grade and quality. According to the International Fabricare Institute (IFI), the average life expectancy of suits is from two to four years, depending on fabric types and quality (Brown & Rice, 2001). Due to rapid fashion changes, consumers may purchase and dispose of apparel products often. Without an effective material management plan for these used apparel products, the apparel industry will have a huge environmental impact related to solid waste and depletion of valuable natural resources.

The C2CAD model and the description of implementation of C2CAD into the knitwear industry can provide a guideline for apparel designers and manufacturers who want to realize sustainable development aspects in their work. Using the C2CAD model, apparel designers and manufacturers select chemicals and materials based on inherent qualities of human and environmental health and safety. Therefore, employee occupational safety and the living quality of the local population will be improved. Without harmful air, water, and solid waste release from apparel manufacturers, both the manufacturer and the local community will save much money in pollution prevention and treatment in the short and long term. With materials designed to cycle safely at the end of the products' life, the C2CAD model also helps diminish resource consumption by the apparel industry.

Study of consumers' opinions will be beneficial to apparel designers and manufacturers by showing that consumers are willing to purchase EFC. However, environmental apparel companies should recognize that consumers are very price sensitive and do not disregard clothing's other characteristics in favor of environmental benefits. Therefore, the apparel company needs to endeavor to make design and quality development a priority while implementing sustainable development.

The acceptance of EFC was more closely related to the degree of the individual's environmental concerns rather than their product involvement. In addition, this study found that lack of information and unavailability were consumers' reasons for not purchasing EFC. Apparel companies need to find effective methods to give information to consumers to increase their environmental concerns and knowledge and to change environmental attitudes and behavior. From follow-up discussion, this study found that some of the respondents (about 25%) had never heard of organic cotton, wool, or hemp clothing or EFC before. When the author mentioned that she could find environmentally friendly clothing through online searches, some of them wanted to know the website addresses of these online retailers. If parents in this study were interested in these online retailers, perhaps organic clothing suppliers would get more business if more consumers were aware of their existence.

Recommendations for Further Study

This study provides a number of recommendations. The first recommendation is that the C2CAD model be applied in other apparel sectors such as in woven, jersey, or jean products. The current study established that the C2CAD model can be employed successfully to develop knitwear production with biological nutrients. Improvements and modifications could be made to the model based on applications to other apparel sectors or technical nutrients.

In addition to safety of material inputs and sustainable material flows, considerations regarding sustainability in production include energy use, air emissions, water, and solid waste. Collaborations with other industries, such as companies that produce renewable energy or use solid waste from apparel production as their biological nutrients or raw materials, are needed to reduce or eliminate harmful impacts during production. Further research efforts could examine the energy efficiency and waste products of the apparel production process by utilizing the C2CAD model.

In cost analysis, it was discovered that the actual purchasing price for organic cotton yarns was cheaper than traditional cotton yarns because the company selling organic cotton yarns had a shorter supply chain. Therefore, another recommendation for further research may be evaluation of the supply chains for sustainable development.

This study used buying scenarios to examine whether or not pricing influences consumers' actual purchasing decisions. However, this study used only one type of children's clothing. Method development is needed to measure other actual purchasing scenarios for further research. In addition, this study considered organic cotton clothing as environmentally friendly clothing. More varieties of EFC exist, and research into exact criteria for EFC will be necessary to develop an accepted, field-wide definition.

REFERENCES

AATCC (2004), AATCC Technical Manual, American Association of Textile Chemists and Colorists, North Carolina.

Akermark, A.M. (2003). *The crucial role of the designer in EcoDesign*. Doctoral dissertation, Kungliga Tekniska Hogskolan, Sweden.

Anderson, R.C., Laband, D.N., Hansen, E.N., & Knowles, C.D. (2005). Price premiums in the mist. *Forest Products Journal, 55*(6), 19-22.

ASTM (2004), Annual Book of ASTM Standards, Vol 07, American Society for Testing and Materials, Philadelphia.

Ball, S. T. (1999). Defoliants, desiccants, and growth regulations used on New Mexico cotton. *Cooperative Extension Service*, Guide A-217, 1-8. Retrieved January 12, 2006, from http://cahe.nmsu.edu/pubs/_a/A-217.pdf

Berry, D. (2005). Lab talk: Many reasons to go organic. *Dairy Foods, 106*(10), 60

Bhate, S. & Lawler, K. (1997). Environmentally friendly products: Factors that influence their adoption. *Technovation, 17*(8), 457-465.

Bjørner, T.B., Hansen, L.G., & Russell, C.S. (2004). Environmental labeling and consumers' choice – an empirical analysis of the effect of the Nordic Swan. *Journal of Environmental Economic and Management, 47*, 411-434.

Bohlen, G., Schlegelmilch, B., & Diamantopoulos, A. (1993). Measuring ecological concern: A multi-construct perspective. *Journal of Marketing Management, 9*, 415-430

Braungart, M (2002). *Intelligent Materials Pooling: Evolving a Profitable Technical Metabolism*. Retrieved November 12, 2004, from the http://www.mbdc.com/features/feature_sep2002.htm

Brown, P. & Rice, J. (2001). *Ready-To-Wear Apparel Analysis*. (3rd ed). New Jersey: Prentice Hall.

Bunin, L.J. (2001).*Organic Cotton: The Fabric of Change*. Doctoral dissertation. University of California. Santa Cruz.

Butler, S.M., & Francis, S. (1997). The effects of environmental attitudes on apparel purchasing behavior. *Clothing and Textile Research Journal, 15(2)*, 76-85.

Cao, H., Frey, L., V., Farr, C. A. and Gam, H. (2006), "An environmental sustainability course for design and merchandising students", *Journal of Family and Consumer Sciences*, Vol 98 No 2, pp. 75-80.

Chan, R.Y.K. (2001). Determinants of Chinese consumers' green purchase behavior. *Psychology & Marketing, 18*(4), 389-413.

Chen, X., Au, W.M., & Li,K. (2004). Consumption of children's wear in a big city in central China: Zhengzhou. *Journal of Marketing Management, 8(*2), 154-165.

Corral, C.B. (1999). Brand name clothing, baby superstores are among the recent retail trends aimed at babies. *Discount Store News*, 38.

Crofton, F. S. (2000), "Educating for sustainability: opportunities in undergraduate engineering", *Journal of Cleaner Production*, Vol 8 No 5, pp. 379-405.

Darian, J.C. (1998). Parent-child decision making in children's clothing stores. *International Journal of Retail & Distribution Management, 26*(11), 421-428.

Diamantopoulos, A., Schlegelmilch, B. B., Sinkovics, R.R., & Bohlen, G.M. (2003). Can socio-demographic still play a role in profiling green consumer? A review of the evidence and an empirical investigation. *Journal of Business Research, 56*, 465-480.

Duff, R. (January 20, 2006). Ecology and health release final plan for problem flame retardants. *US Fed News Service*, Including US State News.

D'Souza, C. (2004). Ecolabel programmes: A stakeholder (consumer) perspective. *Corporate Communications, 9*(3), 179-188.

Environmental News. (April, 1, 2000). *Environmental Science and Technology , 34*(7), 163A

Fiksel, J. (2003). Designing resilient, sustainable systems. *Environmental Science & Technology, 37*(23). 5330-5339.

Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention and behavior. Reading, MA: Addison-Wesley.

Fotopoulos, C. & Krystallis, A. (2002). Purchasing motives and profile of the Greek organic consumer: A countrywide survey. *British Food Journal, 104*, (9), 730-765

Fraj, E. & Martinez, E. (2006). Environmental values and lifestyle as determining factors of ecological consumer behavior: an empirical analysis. *Journal of Consumer Marketing, 23*(3), 133-144.

Frings, G. S. (2005). *Fashion: from Concept to Consumer* (8th ed). New Jersey: Prentice Hall.

Frankel, N. & Leonard, R. (2000). Green design needs leadership. *Facilities Design & Management, 19*(5), 56-60.

Funk, P. (2003). Field oven used to cook up alternative to cotton defoliation. *Resource, 10*(5), 3

Gardyn, R. (2003). Eco-friend or foe? *American Demographics, 25*(8), 12-13.

Gaskill, L.R. (1992). Toward a model of retail product development: A case study analysis. *Clothing and Textiles Research Journal, 10*(4), 17-24.

Glock, R.E., & Kunz, G.I. (1995) *Apparel Manufacturing*. (2nd ed). New Jersey: Prentice Hall.

Goan, M.J. (1996). *An integrated approach to environmentally conscious design and manufacturing.* Doctoral dissertation. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Guerena, M., & Sullivan, P. (2003). *Organic Cotton Production*. Retrieved November, 22, 2005 from http://attra.ncat.org/attra-pub/PDF/cotton.pdf

Hakkio, S. Lassksonen, P. (1998). Relationships in marketing channels: examining communication abilities through cognitive structures. *Psychology & Marketing, 15*(3), 215-240.

Hamel, J., Dufour, S., & Fortin, D. (1993). *Case Study Methods*. CA: Sage Publications.

Harris, P. (1996). Textile makers tap DOE labs for enviro-technologies. *Environmental Management Today, 7*(4), 22-24.

Hendrickx, I. (1995). *Pollution prevention studies in the textile wet processing industry*. Doctoral dissertation. Virginia Polytechnic Institute and State University

Hessel, C., Allegre, C., Maisseu, M., Charbit, F., & Moulin, P. (2007). Guidelines and legislation for dye house effluents. *Journal of Environmental Management, 83*, 171-180.

Holdway, R., Walker, D., & Hilton, M. (2002). Eco-design and successful packaging, *Design Management Journal*, 45-53.

Hose, G.C., Lim, R.P., Hyne, R.V., & Pablo, F. (2003). Shout-term exposure to aqueous endosulfan affects macroinvertebrate assemblages. *Ecotoxicology and Environmental Safety 56*, 282-294.

Jang, N. (2001). *Apparel Product Development: Influential Factors of Apparel Product Success and Failure*. Doctoral dissertation.University of Missouri-Columbia.

Jones, P., Clarke-Hill, C., Shears, P. & Hillier, D. (2001). Retailing organic foods. *British Food Journal, 103*(5), 358-365.

Kadolph, S.J. & Langford, A.L. (2002). *Textiles*. New Jersey: Prentice Hall.

Kamila, A.Y. (2003). How three green businesses survive in the U.S. textile industry collapse. *In business, 25*(3), 10-11.

Kim, H., & Damhorst, M.R. (1998). Environmental concern and apparel consumption. *Clothing and Textiles Research Journal, 16*(3), 126-133.

Klonsky, K., Tourte, L., Swezey, S., & Chaney, D. (1995) *Production practices and sample costs for organic cotton*. University of California Cooperative Extension. Northern San Joaquin Vally.

Köksal, M. H. (2007). Consumer behavior and preference regarding children's clothing in Turkey. *Journal of Fashion Marketing and Management, 11*(1), 69-81.

LaBat, K.L. & Sokolowski, S.L. (1999). A three-stage Design Process applied to an industry-university textile product design project. *Clothing and Textile 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*, Vol 10 No 2, pp. 42-47.

Lannuzzi, A. & Haviland, R. T. (2006). Design for the environment at Johnson & Johnson: A product design process. *Environmental Quality Management*, 43-50.

Laroche, M., Bergeron, J., &Barbaro-Forleo, G. (2001). Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing, 18*(6), 502-520.

Ling-yee, L. (1997). Effect of collectivist orientation and ecological attitude in actual environmental commitment: The moderating role of consumer demographics and product involvement. *Journal of International Consumer Marketing, 9*(4), 31-53.

M2 Presswire (December 28, 2005). UK government: Consumers urged to get to grips with green labels. Coventry, p1

Mackenzie, D. (1997). *Green design: Design for the environment* (2nd ed.). London: Laurence King.

Marshall, C. & Rossman, G.B. (1995). *Designing Qualitative Research* (2nd ed.). CA: Sage Publication.

Marquardt, S.(2001). Organic Cotton: Production and Marketing Trends, *Proceedings of Beltwide Cotton Conference*, Anaheim, CA, January 9-13, 2001.

May-Plumlee, T., & Little, T.J. (1998). No-interval coherently phased product development model for apparel. *International Journal of Clothing Science and Technology, 10*(5), 342-364.

McConnell, J. (1998), Organic cotton clothing. *Mothering*, 88, 36-39.

McDonough, W. & Braungart, M. (2001). *Reinventing the World: building a hopeful path to prosperity with innovative design*. Retrieved November 12, 2004, from the http://www.mbdc.com/feature_may2001.htm

McDonough, W. & Braungart, M. (2002). *Remarking the Way We Make Things: Cradle to Cradle*. New York: North point press.

McDonough, W., Braungart, M., Anastas, P. T. and Zimmerman, J. B. (2003), "Applying the principles of green engineering to cradle-to-cradle design", *Environmental Science and Technology*, Vol 37, pp. 435A-441A.

Meyer, A. (2001). What's in it for the customers? Successfully marketing green clothes. *Business Strategy and the Environment, 10*(5), 317-330.

Mihelcic, J.R., Crittenden, J.C., Small, M.J., Shonnard, D.R., Hokanson, D.R., Zhang, Q., Chen, H., Sorby, S.A., James, V.U., Sutherland, J.W. & Schnoor, J.L. (2003). Sustainability science and engineering: The emergence of a new metadiscipline. *Environmental Science &Technology, 37*(23), 5314-5324.

Mowen, J., C., & Minor, M. S. (2001). *Consumer Behavior: A Framework.* Prentice Hall, New Jersey.

Müzzinoğlu, A. (1998). Air pollutant emission potentials of cotton textile manufacturing industry. *Journal of Cleaner Production, 6,* 339-347.

Murphy, R., M. (2004). Truth or scare. *American Demographics, 26*(2), 26-32.

National Cotton Council of America (2005). U.S. Cotton economic situation and issues update. Retrieved November 12, 2005, from http://www.cotton.org/issues/2005/upload/EconOutlookIssues.pdf

Nimon, R.W. (1999). Eco-labels: *Their impact on domestic markets and international trade flows.* Doctoral dissertation. North Carolina State University. North Carolina.

Nimon, W., & Beghin, J. (1999). Are eco-labels valuable? Evidence from the apparel industry. *American Journal of Agricultural Economics, 81*(5), 801-811.

Nolan, K. (2006). Wal-Mart first mass retailer to offer organic clothing. *DNR Retailing Today, 45*(9), 20.

Pahl, , G. & Beitz, W. (1996). *Engineering Design: a Systematic Approach*. New York: Springer-Verlag.

Papanek, V. (1971). *Design for the real world: Human ecology and social change* (1st American ed.). New York: Pantheon Books.

Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods* (3rd ed.). CA: Sage Publication.

Peralta-Zamora, P., Kunz, A., Moraes, G., Pelegrini, R., Moleiro, P., Reyes, J., & Durán, N. (1999). Degradation of reactive dyes I. A comparative study of ozonation, enzymatic and photochemical processes. *Chemosphere, 38*(4), 835-852.

Pitimaneeyakul, U. (2001). *Product development in the knitwear industry: A case study*. Doctoral dissertation. University of Minnesota.

Prendergast, G. & Wong, C. (2003). Parental influence on the purchase of luxury brands of infant apparel: An exploratory study in Hong Kong. *Journal of Consumer Marketing, 20*(2), 157-169.

Prudhomme, G., Zwolonski, P., & Brissaud, D. (2003). Integrating into the design process the needs of those involved in the product life-cycle. *Journal of Engineering Design, 14*(3), 333-353.

Regan, C. L., Kincade, D.H. & Sheldon, G. (1998). Applicability of the engineering design process theory in the apparel design process. *Clothing & Textiles Research Journal, 16*(1), 36-46.

Ren, X. (2000). Development of environmental performance indicators for textile process and product. *Journal of Cleaner Production, 8*, 473-481.

Scarborough, M.E., Ames, R.G., Lipsett, M.J., & Jackson, R.J. (1989). Acute health effects of community exposure to cotton defoliants. *Archives of Environmental Health, 44(*6), 355-360.

Solomon, M.R. & Rabolt, N., J. (2004). *Consumer Behavior in Fashion*. New Jersey: Prentice Hall.

Speer, J.K. (May 2005). Organic cotton: Where, why and how. *Apparel, 46*(9), 29-30.

Swezey, S.L. & Goldman, P. (1996). Conversion of cotton production to certified organic management in the Northern San Joaquin Valley: Plant development, yield, quality, and production cost. *Proceedings of Beltwide Cotton Conferences*, Nashville Tennessee, 167-172.

Ton, P. (1995). *The European Market for Organic Cotton and Textiles: A Market Survey*. Amsterdam: Foundation for Ecooperation.

United Nations (2005). World summit outcome. Available online at http://ec.europa.eu/comm/external_relations/un/docs/050915_un_summit.pdf.

United States Department of Agriculture: National Agricultural Statistics Service (USDA NASS). (October 2004). *Agricultural Chemical Usage 2003 Restricted Use Summary*. Retrieved September 6, 2005, from the http://usda.mannlib.cornell.edu

U.S. Environmental Protection Agency (1996), "Best management practices for pollution prevention in the textile industry", EPA Manual 625R96004, Retrieved November 12, 2004, from the http://www.p2pays.org/ref%5C02/01099/0109900.pdf.

U.S. Environmental Protection Agency (1997), "Source Reduction Program Potential Manual: A Planning tool", EPA Manual 530R97002. Retrieved November 12, 2004, from http://www.epa.gov/epaoswer/non-hw/reduce/reduceit/#manual.

U.S. Environmental Protection Agency (2000), "Interim Registration Eligibility Decision (IRED) for Tribufos", EPA Manual 738R00022", Retrieved November 12, 2004, from the http://www.epa.gov/REDs/2145ired.pdf.

United States Census Bureau. (2006). Current Population Survey. Retrieved March 14, 2007 from http://www.census.gov/hhes/www/income/income05.html

Verdon, J. (October, 4, 2003). Sales of baby clothing increases over 20 percent in 2002. *Record, The (Hackensack, NJ)*.

Watkins, S. M. (1988), "Using the design process to teach functional apparel design", *Clothing and Textiles Research Journal*, *7*(1), 10-14.

Wickett, J.L., Gaskill, L.R., & Damhorst, M.L. (1999). Apparel retail product: Model testing and expansion. *Clothing and Textile Research Journal, 17*(1), 21-35.

Workman, J.E., Caldwell, L.F. & Kallal, M.J. (1999). Development of a test to measure spatial abilities associated with apparel design and product development. *Clothing & Textiles Research Journal*, *17*(3), 128-133.

World commission on environment and development. (1987). *Our Common Future*. Oxford: Oxford University Press.

Yin, R.K. (1993). *Applications of Case Study Research* (2nd ed.). CA: Sage publication.

Young, C., Jirousek, C., & Ashdown, S. (2004). Undesigned: A study in sustainable design of apparel using post-consumer recycled clothing. *Clothing and Textiles Research Journal, 22*(1/2), 61-68.

Zaichkowsky, J.L. (1994). The personal involvement inventory: reduction, revision, and application to advertising. *Journal of Advertising, 23*(4), 59-70.

Zimmer, M. R., Stafford, T.F., & Stafford, M.R. (1994). Green issues: Dimensions of environmental concern. *Journal of Business Research, 30*(1) 63-74

APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD (IRB)

Oklahoma State University Institutional Review Board

Date:	Thursday, July 27, 2006
IRB Application No	HE0686
Proposal Title:	Development of a Sustainable Apparel Design and Production Model
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved   Protocol Expires: 7/26/2007

Principal Investigator(s

Hae Jin Gam 434A HES Stillwater, OK 74078	Huantian Cao 434A HES Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 415 Whitehurst (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

Oklahoma State University Institutional Review Board

Date:	Thursday, December 14, 2006
IRB Application No	HE06116
Proposal Title:	Development of a Sustainable Apparel Design and Production Model
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved   Protocol Expires: 12/13/2007

Principal Investigator(s

Hae Jin Gam
245 N. Univ. Pl. #302
Stillwater, OK 74075

Huantian Cao
434A HES
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☑ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

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Sincerely,

Sue C. Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

APPENDIX B

INTERVIEW PROTOCOL

Manufacturer Observations

Factory locations:

Size of Factory:

Age of Factory:

Types and quantity of other production related equipment:

Number of persons present and their involvement in production related tasks:

Interview Questions

Part I. Identifying the apparel design and production process (For designers)

1. Please describe the design/production process
2. Please generate the charts of design /production process
3. What is your responsibility?
4. When you select materials, what factors do you consider?
5. What kind of information do you achieve before you design?
6. What else information do you want to achieve?
7. What other market research do you/your company do?
8. Is there anyway to improve the design and production process?
9. Do you have any suggestion about the design and production process in the company?

Part II. Identifying how the apparel company realizes sustainable development issues

1. Have you ever been considered that you have a responsibility for environmental impacts?

2. Have you ever been recognized that materials that you select for your design may pollute environments?
    a. If you did, what kind of problems can be occurred?
3. Have you ever been considered that clothing that you design may pollute environments?
4. Have you ever been considered the end of life of clothing that you design and produce?
5. Have you ever been considered yourself who has responsibility to make clothing environmentally?
6. What do you think could make the clothing more environmentally friendly?
7. If there is available information about materials, what kind of information do you want to receive?
8. Would you like to obtain information of material about environmental impacts?
9. Does your company have mentioned environmental impacts of your company's products?
10. Is there any effort to reduce environmental impacts in your company?
    a. If so, what are those?
11. Do you have any suggestion that how apparel designer can reduce environmental impacts?

APPENDIX C

SURVEY INSTRUMENT

SURVEY INSTRUMENT

Q1 In what year were you born?

____

Q2 Gender

(_____) Male
(_____) Female

Q3 Are you _________________ ?

(_____) Married
(_____) Never married
(_____) Divorced
(_____) Widowed or separated
(_____) Married, but living apart

Q4 What is the highest level of education you have completed?

(____) Less than high school
(____) Some high school
(____) High school graduate
(____) Some technical school
(____) Technical school graduate
(____) Some college
(____) College graduate (bachelor's degree, BA, BS)
(____) Post graduate or professional degree (master, doctorate, MS, MA, PhD, Law degree, Medical degree)
(____) Other ___________________

Q5 What race do you consider yourself? (Can select more than one)

(____) White (Caucasian)
(____) Black (African American)
(____) Asian or Pacific Islander
(____) Hispanic
(____) Native American or American Indian
(____) Other ___________________

Q6 What is your employment status?

(____) Full-time
(____) Part-time
(____) Unemployed
(____) Other ___________________

Q7 What is your occupation?

____

Q8 What is your household income (before taxes)?

(____) Less than $20,000
(____) $20,001-$35,000
(____) $35,001-$50,000
(____) $50,001-$60,000
(____) $60,001-$75,000
(____) $75,001-$90,000
(____) $90,001-$100,000
(____) $100,001-$150,000
(____) $150,001 or more

Q9 In what city do you live? (Please include Zip code)

____

Q10 How many family members, including children, are in your household?

____

Q11 How many children do you have in your household?

____

Q12 How old are the children?

____

Q13 How often did you purchase clothing for your children in the last 12 months?

(____) Once a week
(____) Once a month
(____) Twice a month
(____) Once every 3-4 months
(____) Once every 5-6 months
(____) Once or twice a year
(____) Other ___________________

Q14 On average, how much do you spend on children's clothing each time you go shopping?

(____) Less than $10
(____) $10- $19
(____) $20- $39
(____) $40- $59
(____) $60- $79
(____) $80- $99
(____) $100 - $ 199
(____) Other ___________________

Q15 Do you have a favorite **brand** (Yes ________, No ________) or **store** (Yes ________, No __ _______) for children's clothing?

If yes, please write the name of

the favorite brand(s) ____________________

or the favorite store(s)__________________________

Q 16 Please CIRCLE the number which best describes your opinion about **children's clothing**.

(Do not reply to terms you do not believe apply)

To me [children's clothing] is			
A.	Important	1 2 3 4 5	Unimportant
B.	Interesting	1 2 3 4 5	Boring
C.	Relevant	1 2 3 4 5	Irrelevant
D.	Exciting	1 2 3 4 5	Unexciting
E.	Means a lot to me	1 2 3 4 5	Means nothing
F.	Appealing	1 2 3 4 5	Unappealing
G.	Fascinating	1 2 3 4 5	Mundane
H.	Valuable	1 2 3 4 5	Worthless
I.	Needed	1 2 3 4 5	Not needed

Q17 Please CIRCLE the number which best describes your opinion about **organic cotton clothing**.

(Do not reply to terms you do not believe apply)

To me [organic cotton clothing] is			
A.	Important	1 2 3 4 5	Unimportant
B.	Interesting	1 2 3 4 5	Boring
C.	Relevant	1 2 3 4 5	Irrelevant
D.	Exciting	1 2 3 4 5	Unexciting
E.	Means a lot to me	1 2 3 4 5	Means nothing
F.	Appealing	1 2 3 4 5	Unappealing
G.	Fascinating	1 2 3 4 5	Mundane
H.	Valuable	1 2 3 4 5	Worthless
I.	Needed	1 2 3 4 5	Not needed

Q18 Have you purchased environmentally friendly clothing before?

(____) Yes
(____) No → If No → Q18-2
(____) Don't know → Go to Q19

If No:

Q18-2 Why not?
(_____) Expensive
(_____) Not available
(_____) No difference
(_____) Do not like design and color
(_____) Poor quality
(_____) Don't know

If Yes:

Q18-1-1 What type of items have you purchased?

(_____) Organic cotton clothing
(_____) Organic hemp clothing
(_____) Organic wool clothing
(_____) Recycled polyester
(_____) Other _______________

Q18-1-2 What were your reasons for purchasing environmentally friendly clothing?

(_____) Quality
(_____) Design and color
(_____) Health issues
(_____) Status
(_____) Environmental protection
(____) Other _______________

Q19 Are you willing to purchase environmentally friendly clothing?

(__) Yes
(__) No → If No → Q19-2
(__) Don't know → Go to O20

If No:

Q19-2, Why not? _____________

____

If Yes:

Q19-1-1 What kind?_____________________________________

Why?____

Q19-1-2 In order to purchase environmental friendly clothing, are you willing to switch from your favorite brands or stores?
(_____) Yes
(_____) No
(___) Don't know

Q19-1-3 If yes, are you willing to pay more for environmentally friendly clothing?
(_____) Yes → Q19-1-4
(_____) No
(___) Don't know

Q19-1-4, How much?
________________%

Instructions: Circle ONE number that most closely corresponds to how strongly you agree or disagree with each statement. Remember: Circling **1** means that you **strongly disagree** with the statement: Circling **5** means you **strongly agree** with the statement: Circling **3** would indicate that you are **neutral** and neither agree nor disagree.

Q 20	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Much of the food I eat is contaminated with pesticides.	1	2	3	4	5
Many products that are made from cotton treated with pesticide may contain pesticide residues after producing into fabric	1	2	3	4	5
I think that the government should do more to help control pollution of the environment.	1	2	3	4	5
I think some industries are causing pollution.	1	2	3	4	5
In our country, we have so much electricity that we do not have to worry about conservation.	1	2	3	4	5
Recycling is important to save natural resources.	1	2	3	4	5
Recycling will reduce pollution.	1	2	3	4	5
Textile dyeing releases chemicals and therefore pollutes water.	1	2	3	4	5
Plastic bags take hundreds of years to decompose, thus they cause serious pollution	1	2	3	4	5
I always read products' labeling and consider the environmental impact when making my selection.	1	2	3	4	5

Instructions: Circle ONE number that most closely corresponds to the frequency in which you perform each statement.

Q 21	Never	Rarely	Sometimes	Often	Always
When I have a choice, I purchase organically grown fruit and vegetables	1	2	3	4	5
I recycle newspapers	1	2	3	4	5
I recycle glass	1	2	3	4	5
I recycle plastics	1	2	3	4	5
I recycle cans	1	2	3	4	5
I do not buy from companies that are not environmentally responsible	1	2	3	4	5
When I have a choice, I purchase environmentally friendly products	1	2	3	4	5
When I have a choice, I purchase recycled paper products	1	2	3	4	5

Q22 Out of the 2 apparel items shown to you, please circle the item that you most preferred.

(1)

(2)

Q23 Please rank the reasons for your selection.

(____) Design
(____) Quality
(____) Fabric
(____) Softness
(____) Price

Please, write other comments about these products.

____

APPENDIX D

LETTER TO MOTHERS OF PRESCHOOLERS GROUP

Dear [the name of Present of MOPS Group]

Thank you for speaking with me over the phone. I hope that your MOPS group will consider hosting me to conduct a research survey to complete my dissertation. Currently, I am an Apparel Merchandising PhD candidate at Oklahoma State University, and your groups' participation would be greatly appreciated. Not only will your participation assist in the completion of my dissertation, but also it would give your group the unique opportunity to participate in possible future improvements in young children's apparel.

If your group chooses to host me, I would like to meet at your group's convenience, and I would also like to provide the refreshments for the meeting. As I stated over the phone, the survey should take no longer than 20 minutes from start to finish. Again, I am very appreciative of your consideration to host my survey, and I want to be totally accommodating to your group's schedules and desires. Therefore, I want you to feel free to pick the most convenient situation for your group.

Please feel free to call me at (405) 744-5035 or e-mail me at haejin.gam@okstate.edu to let me know your decision.

Thank you for your time and consideration in this matter.

Hae Jin Gam

APPENDIX E

MANIPULATED CLOTHING TAG

Scenario 1: Organic Cotton is 60% More Expensive

Scenario 2: Organic Cotton is 30% More Expensive

Scenario 3: Organic Cotton is No Price Difference

VITA

HAE JIN GAM

Candidate for the Degree of

Doctor of Philosophy

Thesis: DEVELOPMENT AND IMPLEMENTATION OF A SUSTAINABLE APPAREL DESIGN AND PRODUCTION MODEL

Major Field: Human Environmental Sciences
Area of Specialization: Design, Housing and Merchandising

Biographical:

Personal Data: Born in Seoul, Korea, on May 11, 1974, daughter of Taejun Gam and Changok Pyun. Married to Jun-Young Hur on April 25, 1998.

Education: Graduated from Kyunggi Women's High school, Seoul, Korea in, 1993; received Bachelor of Science degree in Computer Sciences from Seoul Women's University, Seoul, Korea in February, 1998; received Master of Science degree in Clothing and Textiles from the Chung-Ang University in 2002; completed the requirements for the Doctor of Philosophy Degree at Oklahoma State University in May, 2007.

Experience: Instructor for mathematics academy. 1994-1996; Sales Associate, 1997, Knitwear Designer for Maeil company, 1997-2001; Head Designer for Mi-Dong promotion company, 2001-2002; Graduate Research Assistant, Design, Housing and Merchandising Department, Oklahoma State University, 2003 to 2007; Assistant Professor, Illinois State University, Normal, IL, 2007.

Professional Memberships: International Textile and Apparel Association (ITAA); American Association of Family and Consumer Sciences (AAFCS).

Name: Hae Jin Gam Date of Degree: May, 2007

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: DEVELOPMENT AND IMPLEMENTATION OF A SUSTAINABLE APPAREL DESIGN AND PRODUCTION MODEL

Pages in Study: 165 Candidate for the Degree of Doctor of Philosophy

Major Field: Human Environmental Sciences
Area of Specialization: Design, Housing and Merchandising

Scope and Method of Study: Many environmental problems related to the apparel industry, such as toxicity in dyeing wastewater, could be minimized by apparel designers and manufacturers. McDonough and Braungart's "Cradle to Cradle" model provides designers with a new way to design products and eliminate many environmental problems during the design phase of the product life cycle. However, no apparel design and production model considered the designer's role in environmental sustainability. The purpose of this study was to develop, implement, and evaluate an apparel design and production conceptual model by integrating "Cradle to Cradle" into apparel design and production models (C2CAD) to provide sustainable production guidelines for apparel designers and manufacturers. The methods used for this study included the following steps (1) assess the price of organic and non-organic cotton yarns; (2) assess the colorfastness of selected natural and environmentally friendly and non-toxic dyes; (3) develop children's sweater designs; (4) produce prototype sweaters; and (5) assess consumer acceptance of organic cotton children's clothing.

Findings and Conclusions: The C2CAD model was developed by integrating McDonough and Braungart's "cradle to cradle" model into existing apparel design and production models (LaBat and Sokoloskwi, 1999; May-Plumlee and Little, 1998). The C2CAD model has four main steps: 1) problem definition and research, 2) sample making, 3) solution development and collaboration, and 4) production. Following the four steps and with an international collaboration similar to current apparel industry practices, "Four-season sustainability" children's knitwear was developed. Produced with an acceptable manufacturing cost, the products have good mechanical and color fastness performance.
The investigation of consumers' opinions of environmentally friendly clothing was conducted, and recommendations for the apparel industry and future research were discussed.

ADVISER'S APPROVAL: Dr. Cheryl Farr