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# Addressing Sustainable Apparel Design Challenges With Problem-Based Learning

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## Abstract

As consumers' social and environmental concerns have grown in the last decade, so has interest in eco-fashion. Behind fast-changing fashion trends, the apparel industry generates substantial environmental and resource depletion problems throughout the textile lifecycle. To respond to these trends, fashion designers and merchandisers have been motivated to practice sustainability in design and production. Some sustainable options are available, such as organic fibers and environmentally safe dyes. Still, there are challenges for apparel designers and merchandisers when trying to realize sustainability. To help undergraduate apparel students learn problem-solving approaches to sustainable garment design, a problem-based learning project was created and implemented in an undergraduate design course. In the course, students designed and produced an original sustainable garment. Student feedback following the project was largely positive, with most students indicating they would continue using sustainable practices in future work.

## Keywords

sustainable design, design challenge, apparel design, recycling, post consumer, problem-based learning

Sustainability in apparel design is a subject of increasing importance. The apparel industry can create many environmental problems, including large quantities of harmful waste that are generated at every stage of the apparel manufacturing process. Along with increasing global awareness of environmental problems, consumers' awareness of sustainability has risen as well. Consumers are seeking environmentally friendly clothing, and producers are exploring ways to meet these demands while keeping an eye on the bottom line. Though consensus exists within the design world that sustainability is a vital topic to explore, little has been written about how to teach this concept. This study suggests one approach to teaching sustainability concepts to undergraduate university students.

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In the past, apparel designers and merchandisers have emphasized a product's functional, aesthetic, and economic aspects during the design process (LaBat & Sokolowski, 1999). With increased consumer interest in the environmental implications of apparel production, many companies have introduced sustainable practices. For instance, companies such as Coop Switzerland, Levi Strauss & Co, Marks & Spencer, Nike, and Noir use organic cotton (Black & Anderson, 2010; DeLong, 2009; Organic Exchange, 2007). Other companies, such as Patagonia, offer products made from recycled polyethylene terephthalate (PET) bottles (Rupp, 2008). Manufacturers are also offering fabrics made from recycled or regenerated fibers. Martex's "eco2cotton," a fabric made from apparel yardage waste, is one such example (Marks, 2007).

Inspiration in the sustainable apparel design process can be found outside the field of fashion. For instance, an environmental architecture designer and a green chemist developed environmental design guidelines, called "Cradle to Cradle" (McDonough & Braungart, 2002). Products that reflect these guidelines should be designed in ways that do not drain resources and that make use of renewable energy, rather than hydrocarbon-fueled energy. Because designers are the decision makers in every step during the production process, the Cradle to Cradle concept emphasizes the designer's role in achieving sustainability. According to these guidelines, designers should seek to practice environmental responsibility and discover solutions for current problems since designers determine the properties of the products (Pahl & Beitz, 1996). Accomplishing this kind of sustainability requires a delicate balance of alternative choices. Director of Innovation at Nike, Dr. Susan Sokolowski, notes (DeLong, 2009):

And what is sustainability? There are many, many interpretations . . . Do we build a product that is so durable that you never have to replace it? Or do we build products to disintegrate after a reasonable number of wears, so there is no landfill? Or do we create a product that self-cleans itself, so you preserve water resources? What is the best fiber to use—recycled polyester or organic cotton? How do we solve the problem of sustainability without compromising the athlete's performance? (p. 110).

Sustainable practices are growing in some areas of the apparel industry. However, there is little research addressing how we can prepare apparel design students for the challenges they will face in carrying out sustainable practices in the apparel industry postgraduation. Therefore, the purpose of this study was to describe how Problem-Based Learning (PBL) was used to introduce apparel design students to the opportunities and challenges of sustainable apparel design.

## **PBL in Apparel Design and Merchandising**

PBL is an established student-centered, rather than instructor-centered, teaching method with roots in the medical field (Barrows & Tamblyn, 1980). The teaching strategy has won wide acceptance outside medicine as students involved gain practical, hands-on experience applying their content knowledge to solve real-world challenges in the nonthreatening environment of a classroom. Fields of study that have embraced PBL include family and consumer sciences (Ward & Lee, 2002, 2004), business (Brzovic & Matz, 2009; Saatci, 2008), public relations (Attanse, Okigbo & Schmidt, 2007; Smudde & Luecke, 2005), and architecture (Eilouti, 2006). PBL is a good fit in apparel design and merchandising coursework since the methodology is very "hands-on." When implementing PBL, students are typically presented with a problem that practitioners in their industry face on the job. Students locate appropriate information and resources for solving their problem, with the instructor serving in an advisory role throughout the process. It is the students' responsibility to choose the best solution and present findings and support for their decision (Torp & Sage, 2002). Bye (2010) stresses that apparel designers of the future must be strong team members, communicators, and problem solvers—all skills that PBL enhances. Four PBL studies within apparel merchandising-related courses help illustrate the efficacy and advantages of the PBL approach.

Farr, Ownbey, Branson, Cao, and Starr (2005) used a factorial analysis quasi experiment to analyze 155 students' responses. Student groups were introduced to textile science principles regarding colorfastness and resistance to light and heavy abrasion. A course experience questionnaire and a content analysis of student comments and instructor observations indicated PBL was an aid to learning and comprehension and more beneficial to students than traditional lectures alone.

Carpenter and Fairhurst (2005) detailed the design and implementation of a capstone course using PBL in retail merchandising. Participants were required to design a workable business plan using a real business. Participants interacted with the business employees to discover problems, create a mission statement, and propose solutions. Evaluation of the program was based on student and industry partner comments, which were guided by an assessment rubric. Specific areas in which students showed improvement included problem solving, critical thinking, thinking of alternatives, and applying previously learned principles to real-world problems.

In addition, Kimmons and Spruiell (2005) designed a capstone course for interior design, retail merchandising, and graphic arts students utilizing PBL. The final group projects were judged by industry professionals. Researchers assessed the project based on formal and informal evaluations, finding it to be highly successful in achieving success in regard to several pedagogical objectives, including teamwork, practice for the real world, problem-solving skills, professional behavior, "self-directed" learning, and written communication.

Cao, Frey, Farr, and Gam (2006) used a PBL approach in a specialized textile design and merchandising course emphasizing environmentally friendly apparel design. Case studies and two projects were used. Specific areas of benefit included teaching students to think outside the box and broadening the students' scope of innovation. In addition to the learning outcomes, participants indicated the method was "inspiring."

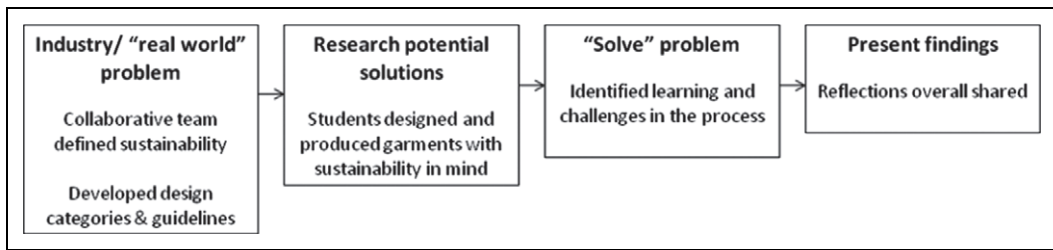
While several of the studies examined included apparel design students as participants, each of the courses highlighted were merchandising courses. Teaching methods specific to apparel design, particularly in regard to PBL, were not found. This research will contribute to teaching methods in apparel design by showing how PBL can be used to teach sustainable design processes.

## **Sustainability Practices in Textiles and Apparel**

Apparel companies have increasingly been incorporating sustainable practices in the last two decades, making it a topic of current relevance in apparel design university curriculum. In the 1990s, apparel companies such as Esprit and Patagonia that valued environmental decision making implemented sustainable apparel design and production processes (Mirvis, 1994). Their practices intensified during the next decade, with the use of renewable materials and natural energy (Solomon & Rabolt, 2004).

In recent years, a more holistic approach toward sustainability has been emphasized, with the green movement extending to a wider range of apparel companies (Black, 2008). The Danish fashion company Noir is an example of a small company seeking to combine high fashion and sustainability (Black & Anderson, 2010). Among the company's biggest challenges has been locating sustainable fabrics that meet both the standards of luxury-brand clients and the organic and fair-trade guidelines. Noir's solution has been to become part of the supply chain through the oversight of organic cotton farms, though this is a time-consuming and resource-draining solution in itself (Black & Anderson, 2010).

Another approach to sustainability has been implemented by the large United Kingdom retailer Marks & Spencer (M&S). This company has introduced strict production standards across the supply chain to reduce the impact of its own brand of products and discontinued the relationship with suppliers, which use certain chemicals or ingredients that cause negative environment impacts (Fletcher, 2008). Due to the size and scale of M&S, this practice influences other large companies



**Figure 1.** Stages of problem-based learning in a sustainability themed fashion show.

to adopt sustainable approaches. The experiences of Noir and M&S illustrate how, today, there are more options than in the past for apparel designers and merchandisers to practice sustainable development.

The wide variety of ways to practice sustainability highlights the first of three challenges within sustainable practices, that of providing one common, specific definition that the entire apparel industry can embrace (Meyer, 2001). Overall, literature suggests that sustainable practices in the textile and apparel complex include the use renewable materials (Joergens, 2006; Poole, Church & Huson, 2009; Solomon & Rabolt, 2004) and/or non-harmful materials (Chen & Burns, 2006; Poole et al., 2009), apply low-impact processes (Allwood, Laursen, Russell, Malvido de Rodríguez, & Bocken, 2008; Chen & Burns, 2006; Poole et al., 2009; Solomon & Rabolt, 2004), and promote the reuse or recycling of waste materials (Chen & Burns, 2006; Fletcher, 2008; Joergens, 2006; Poole et al., 2009).

A second challenge encountered within sustainability is the use of terms to refer to general sustainability. Terms currently used in literature that refer to sustainable practices include not only sustainable but also eco-friendly, green, and environmental friendly. In this research, the term sustainable will be used because it embraces not only the meaning of environmental concerns but also the implication of a variety of opportunities to make a positive, sustainable impact (Hethorn & Ulasewicz, 2008).

A third challenge to sustainable practices in the apparel industry, perhaps one of the biggest barriers encountered, is the fact that fashion trends and seasons make apparel one of the most change-intense categories of consumer products (Kunz, 2005). Consumers are encouraged to over-consume fashion products by fast-fashion retailers, such as H&M, Topshop, and Zara (Birtwistle & Moore, 2007). Apparel companies have made efforts to reduce production costs by using low-cost labor and non-sustainable materials to increase profits in the highly competitive marketplace. These conventional production practices are in direct opposition to what sustainability advocates endorse.

## Method

### *Conceptual Framework*

The motivation for using PBL to teach sustainable design was a sustainability-themed fashion show. Each spring, apparel design and merchandising students at a Midwestern university plan, produce, and carry out all aspects of a fashion show that is regularly attended by several hundred members of the university and surrounding community. The design theme of sustainability allowed apparel design students to explore sustainability concepts in their design and production processes.

To begin the PBL real-world problem of designing sustainable garments, a collaborative design team comprised of apparel design faculty and students first defined sustainability practices from the literature and used the definitions to identify six different sustainable design categories into which apparel designers could enter a potential garment for the fashion show. Second, individual designers worked alone to design garments for the fashion show, while keeping in mind product sustainability.

In this step, individual designers selected materials that met requirements for each design category, constructed, and showed the garment during the fashion show. During this step, faculty members served as resources for the student designers but did not participate in the design process themselves. Focus groups were held with student designers during the third and fourth stages of the PBL process. Challenges encountered through the sustainable design process were articulated by student designers as the third step, while overall reflections about the sustainable design process were shared during the fourth step. Figure 1 visually depicts the conceptual framework used for this study.

The first step in the PBL sustainable design challenge was for a collaborative team of faculty and students to define “sustainable design” and together develop guidelines for sustainable designs that could be included in the fashion show. The guidelines for what could be considered a “sustainable design” for the fashion show were developed with the direction of several studies that related to sustainable design (Black, 2008; Chen & Burns, 2006; Hethorn & Ulasewicz, 2008; Joergens, 2006; Poole et al., 2009). The results of these studies were summarized and used to establish six categories of sustainable design. While these findings are not complete, they helped to identify what options are currently available for the sustainable apparel design practice. For example, utilizing natural dyes can be suggested as potential sustainable practice because it can be an alternative to harmful chemical dyes (Kadolph & Casselman, 2004). Further development is needed, but this categorization was needed to provide students with parameters for sustainable design and increase awareness of current problems. These categories were practiced based on the assumption that if design students met requirements, they practiced sustainability.

In the PBL process, the second step was for apparel design students to design and construct a sustainable garment. Students could submit original garments for the fashion show using organic materials such as organic cotton, wool, or silk (Category 1), using renewable materials such as bamboo, soy, or hemp fabrics (Category 2), using postconsumer clothing (Category 3), reusing non-garment materials (Category 4), using natural or environmentally friendly dyes (Category 5), using innovative pattern techniques that can reduce or eliminate fabric waste (Category 6), or students could choose to combine more than one of the categories together in a garment. In addition, to encourage students to generate innovative ideas and to participate in Category 5, faculty instructors allowed them to use conventional fabrics. A total of 121 sustainable designs from 29 apparel design students were chosen to be presented in the sustainability-themed fashion show.

### *Data Collection and Analysis*

The purpose of this study was to describe how PBL was used to teach apparel design students problem-solving skills related to sustainable design, an area of limited research to date. To obtain both depth and breadth of understanding of student perspectives of the outcome of the PBL sustainable design activity, this study employed a series of three focus group discussions with student designers following the completion of the project and the sustainability-themed fashion show. These focus groups represented Steps 3 and 4 in the PBL process. Focus groups were chosen as a methodology in order to elicit deeper discussion about topics and to allow participants the opportunity to respond to comments made by others in the group, thereby offering richer results than could have been obtained simply using a survey approach. According to Krueger (1995), focus group discussions generate qualitative data that provide insights into participants’ perceptions and opinions on current issues. Analyzing qualitative data allows researchers to closely examine “the meanings and interpretations that individuals, in their own terms, place upon their experiences” (Dickson, 2000, p. 103).

As each focus group session began, individual participants were given a discussion pseudonym to ensure confidentiality and honesty. Five questions asked of the student designers during each focus group session: (1) “How do you define sustainability in the area of apparel?” (2) “What kind of sustainable techniques did you use to create your garment design?” (3) “What were

**Table 1.** Definitions of Sustainability in the Apparel Area

Themes	Representative Statements
The use of environmentally friendly and renewable materials	Choosing organic cotton, hemp, and bamboo fabrics for garment designs
Whole production processes that are safe or good for the environment	Doing what won't harm the earth Trying best whenever possible is sustainable for me Using green energy
Reusing and/or recycling materials	Something that can be used over and over again Modeling the concept of "waste equals food" by using postconsumer clothing or non-garment materials

challenges that you faced when you created and produced your garment?" (4) "What have you learned from this experience?" and (5) "Will you use sustainable practices in the future?" Question 1 reflected PBL Step 1, Question 2 reflected PBL Step 2, Question 3 reflected PBL Step 3, and Questions 4 and 5 reflected PBL Step 4. Researchers took notes during the focus group sessions, and the audio recordings from each group were transcribed for later analysis by the researchers. Observer notes collected during the focus groups and transcriptions were used to analyze the content of the discussion by "examining the text for similarly used words, themes, or answers to questions" (Berg, 2007, p. 162). These themes were conceptualized through the process of open coding (Strauss & Corbin, 1998).

### *Participants Profile*

The target population for this study was apparel design students who designed and constructed at least one sustainable garment for the sustainability fashion show. In keeping with Krueger's (1995) guidelines for effective focus groups, a series of 3 identical focus group sessions were held with between 6 and 8 different participants at each, for a total of 20 participants. The 20 students ranged in age from 19 to 24 years old, each was female, and had created between 2 and 9 garments for the fashion show. The majority of participants were academic seniors (60%), while 30% of them were juniors and 10% of them sophomores.

### **Results**

Focus group participants answered questions regarding their definition of sustainability, which techniques they used to create their garments, specific challenges they faced in the process, what they learned from the experience, and whether or not they would practice sustainable design in the future. Transcription and coding of responses from the focus group discussions allowed researchers to identify themes in the data and make recommendations for future research in this area.

### *Definitions of Sustainability in the Apparel Area*

The first step in the PBL process was to define sustainability. When focus group participants were asked how they defined sustainability in the apparel area, three explanations of sustainability were expressed. The participants' responses emerged into three themes when defining sustainability. The themes were use of environmentally friendly and renewable material, safe production practices, and recycling and are summarized in Table 1. The prevailing answer to this question related to selecting and using sustainable materials, such as organic and renewable fibers and natural dyes. Several participants stated that the word "organic" came up first whenever they thought about sustainability.



The next predominant answer in defining sustainability embraced the whole production process. One of the participants pointed out that using organic fabrics was not enough because they may be dyed with harmful chemicals. Other participants included using renewable energy as part of sustainability, with a participant saying, "I read about one apparel company using wind power energy for their facilities, and I think using green energy should be considered, too."

The third identified theme, reusing or recycling materials, was related to the Cradle to Cradle concept. One participant expressed this best by stating that sustainability is "something that can be used over and over again. It doesn't necessary need to be durable but it just can go on without being thrown away or reused." Some participants modeled the concept of "waste equals food" using postconsumer clothing or non-garment materials, evidenced by a participant who went to a thrift store to purchase old clothing and felt that a lot of clothing in the store could be recreated into new designs. She stated:

Using organic fabrics is expensive, but using post clothing is much cheaper. Thrift stores have lots of clothing . . . whenever I went there I found some post-consumer clothing that can be used for my designs. We can use these to create new designs, and I believe this can reduce lots of waste and be sustainable.

Overall, participants' definitions of sustainability were similar to concepts drawn from the literature review in this study. Perhaps, because participants produced small amounts of clothing, their definitions of sustainability did not extend to mass and global production issues, such as fair trade or carbon footprint.

### *Sustainable Techniques Used for Garment Designs*

The second step in the PBL process was to design and create a garment from sustainable materials. Sustainable garments made by focus group participants represented each category within sustainable design that had been developed in PBL Step 1 by the team of faculty and students for the fashion show. This indicated that a variety of experiences with sustainable design were drawn from during focus group sessions. Among the 96 sustainable garments made by focus group participants, 68 garments were made with organic fabrics (Category 1), 25 with renewable fabrics (Category 2), 33 with post-consumer clothing (Category 3), 12 with reused non-garment materials (Category 4), 19 with natural or sustainable dyes (Category 5), and 7 with innovative pattern techniques to reduce fabric waste (Category 6). Over half of the 96 garments created combined two or more sustainable design techniques, for example, using natural dyes to change the color of organic fabric (Categories 1 and 5).

### *Identified Challenges*

The third step in the PBL process was to identify challenges encountered during the sustainable design process. Defining challenges to sustainable practices for apparel design and production helped apparel design students problem solve a challenge faced by industry professionals while also gaining new content knowledge about an important trend in apparel design. When asked to identify challenges to practicing sustainable design, five main challenges emerged from focus group participants, presented in Table 2. Nearly all participants agreed that organic or renewable materials are more costly than conventional fabrics. Participants who did not articulate a concern over price created wedding dress lines, for which consumers are willing to spend more money.

The second most common theme was limited selection of local or regional resources confined to sustainable products and limited to organic and renewable fabric color choices and notions. One participant noted that she felt limited at the beginning of the sustainable design process because it was difficult to find fabrics in local retail stores. Another participant remedied this situation by ordering her fabrics from an online store, but the choice was not without drawbacks. She expressed frustration

**Table 2.** Identified Challenges

Themes	Representative Statements
Cost of materials	Organic or renewable materials are more costly than conventional fabrics
Limited selection/ low availability of sustainable fabrics	Finding organic materials was kind of difficult because a lot of places just sell it online
Difficulties with sustainable dyes	Can't get those vibrant and bright colors by using natural dyes Obtaining the same color from multiple sessions with natural dyes was almost impossible
Limited fabric available within recycled clothing and textiles	Be really careful with my layout to conserve the fabric because there wasn't much Had to actually change my design because of a limited amount of fabric It's not like you can just go out and buy the same exact design The deconstruction process necessary to make postconsumer products usable required additional time
Limited selection of eco-friendly notions and trims	Obtaining eco-friendly notions, such as recyclable zippers and buttons was difficult Used notions and trims from postconsumer clothing Used conventional notions and trims in an effort to practice easy disassembly

that a swatch had to be ordered first so that she could touch and feel the fabric, followed by more waiting for the final fabrics to arrive.

Because of limited color selections, some participants tried to dye their fabrics to the desired colors. The third theme appeared as participants described dyeing processes. One participant described her challenge in obtaining the colors she wanted:

You have ideas for all these colors before you started working with them and you realize that you can't get those vibrant and bright colors by using natural dyes. You still can get a range of colors if you really work at it, but you can't get the bright colors at all.

Another dyeing challenge was identified by a participant who indicated that obtaining the same color from multiple sessions with natural dyes was almost impossible for her. The participant stated:

If you didn't dye all of your pieces at once it was hard to get the same exact color again . . . until someone can figure out how to regulate natural dyes and make them more uniform, so that colors are more uniform and you can get black and not navy blue, then I think it'll become a bigger trend. But, until then I just don't see people being willing to compromise their design idea for just going organic.

While black organic fabrics have limited availability online, only one participant in this study found the black organic silk fabric she wanted through the Internet.

The fourth identified challenge was having a limited amount of fabric available within recycled clothing and textiles with which to work. Participants who created designs with these materials indicated it was a major challenge. One noted: "I made a dress out of a bed sheet and I had to be really careful with my layout to conserve the fabric because there wasn't much." Another participant elaborated, stating that she actually had to change her design because of a limited amount of fabric. She said:

I had a problem with material usage, like, at first I was going to make a really long dress but then I didn't have enough since I used postconsumer clothes. And it's not like you can just go out and buy the same exact design. You had to make use of what you had.



**Table 3.** What was Learned from Creating Sustainable Designs

Themes	Representative Statements
An attitude change toward sustainability	I thought theme was going to be nightmare. But I learned a lot from the process I think it was just a good challenge [and] something people aren't ready for I do much better [in appreciating] people who've tried to do research [on] how to make everything more eco-friendly
A broadened idea of sustainability	Going thrift stores and taking old clothes apart to make new designs. I never thought I could do that Reducing waste by creating innovative patterns was really cool...It just made me more aware of how many different aspects of design can be eco-friendly
Achieving greater creativity	Having the sustainability theme for the show made me inspired to be more creative I found my stuff, clothes that I used from Goodwill . . . [resulted in a product] more creative than what I've ever thought of before

This challenge suggests that while conserving production materials, sustainable design can actually create more work hours for designers. This, in turn, can drain environmental resources indirectly by eating up resources, such as electricity and research and development materials. In addition to the consumption of more work hours, some participants found the deconstruction process necessary to make postconsumer products usable required additional time, not normally allotted to the design process. Rumsey (2008) indicated that design for disassembly is needed to reduce wasting valuable resources in light of the fact that many apparel products are made with different types of materials. Gam, Cao, Farr, and Heine (2009) indicated that using permanent junctions, stitches, and adhesive are some of the impediments of reusing postconsumer clothing.

The comments of the participants in this study explained how these impediments generate challenges for their practice of sustainability. One participant noted that using postconsumer clothing was a challenge because she had to rip it apart to get materials, which took a significant amount of time and effort. This experience was mirrored by a separate participant who had reused a zipper and tulle from an old prom dress. She agreed that ripping was time-consuming work, but suggested that reusing the materials saved her money.

The final identified challenge to designing for sustainability was in the use of eco-friendly notions and trims. Only three participants could find eco-friendly notions, such as recyclable zippers and buttons, from online stores. The other participants used notions and trims from postconsumer clothing or used conventional notions and trims in an effort to practice easy disassembly.

Selected challenges identified by focus group participants could be attributed to a lack of previous experience with the sustainable design process. For example, utilizing appropriate mordants or treatments to achieve specific desired colors is a skill that students would improve with further training.

### *What was Learned From Creating Sustainable Designs*

The fourth step in the PBL process was to reflect on what was learned during the sustainable design process. Participants' responses to what they learned from creating sustainable designs centered on three common themes and are summarized in Table 3. The first theme related to an attitude change regarding their initial impression of sustainable design. When participants received information about the fashion show theme of sustainability, most thought that their design and available materials would be very restricted. Participants used adjectives such as "limited," "constrained," and "difficult" to describe their initial thoughts and feelings about the project. However, as participants

made progress in developing sustainable designs, their perspectives and concepts related to sustainability changed and became more positive. One participant elaborated:

Two things that I didn't think about before the fashion show were, one, how difficult something can be to do that you want to do it environmentally friendly and sustainable. But I was so surprised at all the really interesting pieces that we made that normal people would never guess were completely environmentally friendly.

The participants also perceived opportunities in sustainable design as the process went on, with some expressing surprise at this unexpected result. "I thought the theme was going to be nightmare. But I learned a lot from the process," noted one participant. Another participant echoed this feeling, stating that even though there was a high level of difficulty, "It is still worthy at the end though because of other benefits."

The second theme emerging from student experiences was that the sustainable design process broadened their perspectives on sustainability. Because participants had not learned about sustainable design in their university curriculum prior to this experience, they had limited ideas for sustainable practice. However, performing and/or watching others utilize new practices, such as using postconsumer clothing, creating innovative patterns to reduce waste, and considering easy disassembly, allowed them to add to their concepts of sustainable apparel.

The third theme that emerged in response to the question about their learning was that the process of sustainable design pushed participants to be more creative. Statements from participants regarding this theme included, "Clothes that I used from Goodwill . . . [resulted in a product] more creative than what I've ever thought of before" and "I spent lots of time thinking about how to be creative to reduce fabric waste from patternmaking. I strategically placed my dress patterns . . . I also altered the dress design a little bit." Those descriptions of the learning experience correspond with Noir's sustainable movement, which contends that fashionability and sustainability should be carried out together (Black & Anderson, 2010).

### *Willingness to Practice Sustainability in the Future*

The fifth focus group question, concerning whether this experience motivated participants to continue to practice sustainability in the future, was also part the fourth step in the PBL process. Participant responses reflected a mixture of positive and negative viewpoints. Most participants agreed that they wanted to continue to practice sustainable design in the future and some indicated that they were inspired to spread the concepts of sustainable designs. One participant summed it up best:

I think besides trying to apply the sustainable practices that we learned, it's going to be introducing the ideas. People around me weren't familiar with postconsumer construction, and so it's going to be us who are introducing the ideas that we have learned here . . . informing people what is Cradle to Cradle, what is design for disassembly and telling them that it's not just organic fabrics that make things sustainable . . . and maybe one day trying to institute a recycle program in a company or something.

The situation also provided some on-the-job training. Because some participants did not know about the innovative pattern-making techniques that can reduce waste or think of the possibility of using postconsumer clothing or other materials, they did not attempt to apply these strategies. Selected participants noted, however, that they wanted to explore the innovative techniques that they watched their classmates practice.

In spite of the many lessons learned throughout the sustainable design experience, some participants reported that they were not interested in practicing sustainability in the future. General comments within this theme included lack of variety of and higher cost for materials and a feeling of restriction and limitation overall in the design process. A specific frustration noted by participants was that a wider variety of colors and textures in organic or other renewable fabrics is not currently available within the apparel industry. Noted one participant:

Until the organic industry really has a lot more variety, I don't think myself or other designers will be willing to sacrifice the bright colors or different varieties of the textures. But, so far it's neat to be able to jump back and forth between using recycled garments and organics.

Overall, focus group responses indicated that when designers have fewer challenges, they will be more likely to choose sustainability. Some participants agreed that they will play an important role in practicing sustainability.

## Discussion and Conclusions

The purpose of this study was to describe how PBL was used to introduce apparel design students to the opportunities and challenges of sustainable apparel design. Based on the findings presented here, PBL proved to be an appropriate method for teaching the selected group of apparel design students about sustainable design practices. The practical nature of the problem to be solved, coupled with the student designers' background experience and enthusiasm for the project, served to increase the problem-solving capacity of students while challenging them to think critically. Ambrose, Bridges, DePietro, Lovett, and Norman (2010) note that "students' motivation determines, directs, and sustains what they do to learn" (p. 5). The high level of motivation exhibited by students to participate in the present study could have played a role in the success of this PBL project. The active learning that was present throughout the sustainable design challenge similarly may have affected the success of the project, a characteristic of learning that has been suggested as being integral to good teaching in higher education (Chickering & Gamson, 1987). Even for the students who expressed their lack of desire to continue using sustainable practices, the skills they gained overall in the activity will increase their employability.

One recommendation for future uses of PBL in apparel design would be to use teams of student designers for one garment, rather than the individual design process that was used for this study. A team approach would give students more experience making decisions as a team, mirroring the current apparel industry. Overall, the researchers recommend the continued use of PBL for design challenges such as sustainability.

Because sustainability is such a significant issue in the apparel industry, more course work in postsecondary education curriculum needs to address this topic as well. Future designers will struggle in their chosen field after graduation if they do not receive appropriate training during their college or university study. A separate class focusing only on sustainability issues also would benefit both design and merchandising students. For example, the Cao et al. (2006) case study illustrated how a science based course to explain textile-related environmental problems could be effectively informative and inspirational to the students.

As a result of what focus group participants shared from their experiences with sustainable design, we also recommend that sustainability as a concept be integrated into various levels of postsecondary curriculum, particularly in hands-on apparel design classes. Experiences ranging from using natural dyes through designing garments with zero fabric waste to sourcing organic fabrics could become individual or group activities in core apparel classes. Pasricha and Kadolph (2009)

suggested this practice, saying that fashion education should incorporate sustainability into curriculum rather than being viewed only as a stand-alone course.

While student designers do not face challenges on the same scale as those in industry, lessons learned from their own individual design challenges and articulated during focus group sessions can be nonetheless informative as students embark on their own apparel design careers postgraduation. As future designers, the students can recognize their role in practicing sustainability and select sustainable materials and methods whenever possible. When designers face challenges, they have the skills to research alternatives and be creative in finding solutions. In some instances, when organic fabrics are too costly, designers may use postconsumer clothing as alternative materials to reuse materials or consider applying innovative pattern-making techniques to reduce solid fabric waste. Each of these solutions would need to be tailored to the designer's specific job assignment and target market.

Students' identified challenges showed different perspectives with existing challenges defined by literature. Two pieces of literature (Fletcher, 2008; Hethorn & Ulasewicz, 2008) identified current challenges to practicing sustainability in fashion: increased consumer desire to consume more clothing and a highly competitive apparel market. The identifications are approached with consumer-oriented and consumption-focused perspectives. The focus group discussions in this study describe challenges from design and material selection perspectives and provide groundwork for sustainability development to overcome the challenges.

Future studies could explore how the integration of sustainability into a university curriculum affects early-career apparel designers. An investigation of apparel designers to see how successfully they can apply their learning in regard to sustainability from university to the current industry can be conducted as a follow-up study.

This study used PBL to expose apparel design students to real-world industry challenges, while acknowledging students' perspectives on sustainable design, challenges, experiences, and willingness to continue using sustainable design. The focus group discussions provided insight into the lessons learned and challenges faced by apparel design students when practicing sustainable apparel design and production, lessons that can be acted on in the students' future careers in the apparel design industry.

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