



TAKING ADVANTAGE OF THE DESIGN POTENTIAL OF DIGITAL PRINTING TECHNOLOGY FOR APPAREL

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ABSTRACT

The integration of digital technologies into apparel forms allows designers to explore and visualize new creative possibilities. How the technology is used and how design concepts are perceived in the industry are areas of crucial importance to the technology's longevity. Our goal, as collaborative artists, focuses on integrating technology into the creative process to create both art and industry-oriented apparel. The applications of digital textile and apparel design have implications for many areas of the industry, but we have focused on three: art-to-wear, custom design, and mass customizable products. The body of research and artwork that we have developed suggests that a systematic approach to integrating new technologies into the textile and apparel design process can be developed, recorded and employed in future design explorations to inspire the most rapid technology integration with the greatest potential for new product conceptualization.

Keywords: Digital textile printing, apparel design, design process, art-to-wear

The integration of digital technologies into apparel forms allows designers to explore and visualize new creative possibilities. How the technology is used and how design concepts are perceived in the industry are areas of crucial importance to the technology's longevity. In a rapidly changing technological environment, the possibilities for new approaches to the design process, changes in production methods and changes in product types need to be addressed by both design researchers and practicing designers. Our goal, as collaborative artists, focuses on integrating technology into the

creative process to create both art and industry-oriented apparel.

When we began our collaborative process, the use of digital printing for apparel was at a rudimentary stage. Most designers and industry professionals either printed flat textiles intended to be cut and sewn into garments through traditional methods, or placed the images in a two-dimensional way on the front or back of the garment. Some attempts were made to have images match across garment seams, but apparel shapes tended to the simplest forms. We aspire

to evolve new design processes through the manipulation of complex garment shapes and different textile surfaces, and with production processes. The collaborative process has been crucial in the ability to expand the range of design possibilities in the integration of two-dimensional digital textile design with three-dimensional apparel designs. When we work collaboratively, our design interactions/roles are not narrowly defined. While the strength of one designer is primarily focused on development of 3-dimensional shapes and the other on digital textile design, the collaborative process involves discussion of all the elements of both design and process. Because we work as a team, our roles are interdependent, and the designs we develop could not have been successfully evolved without the technical and artistic expertise of both.

We believe that this type of collaboration is unique and difficult to quantify in traditional scientific research terms. Historically, there is a long and rich tradition of collaboration between apparel designers and textile artists. Because the medium in which an apparel designer works is fabric, there are numerous ways to approach the transition of textile into garment and the inherent creative processes. At the most elemental, apparel artists/designers obtain fabric from other designers or from traditional manufacturing sources. But collaboration with textile artists/designers is a natural link for an apparel designer and occurs frequently, both in the art-to-wear field and in the apparel industry. This collaboration offers opportunities for richer and more complex development of the interrelationships between textile and apparel form.

Through this collaboration, it has been possible to explore increasingly complex design ideas and to develop methodologies for integrating new technology into the design process. The applications of digital textile and apparel design have implications for many areas of the industry, but we have focused on three: art-to-wear, custom design, and mass customizable products.

Art-to-wear

Initially, and primarily, we collaborate on garments that are intended for display in art-exhibition settings. These pieces explore the limits of what is possible with the new technologies and inform the public and industry as to new design approaches. This focus allows us to take full advantage of the design potentials of the technology without being constrained by the needs of any specific target market.

Our initial collaborative design approach to the creation of art-apparel using digital textile printing was to integrate an innovative garment form with digitally manipulated surface imagery so that a printed design could be engineered to match across the seamlines. The theme of 3-dimensional design development relates to creative exploration of how flat textiles become complex sculptural shapes, how apparel patterns are visualized and developed for industry. We recognized the potential for great difficulty in applying digital printing technology to the creation of non-traditional pattern shapes, due to the need to align odd-shaped pattern pieces. While there would be limited allowance for design changes after fabric printing, it would be a relatively simple process to make design changes on the computer and re-print a second garment.

In general, in our collaborations, one of us develops and produces the 3-dimensional component, while the other develops the surface design. However, as with most collaboration, the creative and experimental process has led to much more complex design thinking and analysis than possible with only one designer. From the beginning, we established an experimental strategy for working with new technology and identified initial questions and directions. Our collaborations continued to involve both more complex shapes and more integrative use of images. In addition, explorations included transformation of the image through layering and reforming the fabric. As the collaborations became more fluent; the designs were conceptualized together, rather than each artist working independently in his/her area of expertise.

As we became more comfortable with the integration of the technology and with the collaborative interactions, one of our explorations focused on two types of visual transformation; restructuring of digitally printed imagery and of the printed fabric itself. Inspired by the potential visual distortion of large floral photographs, we attempted to address the threshold of visual clarity and the recognition of the floral motifs by breaking up and restructuring both the imagery and the fabric. Images of the flowers were contorted to fit the shape of the coat body and fabric with the same printed imagery was cut into strips and re-knit to form cuff, border and hood sections. Sheer fabric was overlaid on the body of the coat. The exact same imagery was printed on both fabric layers; when the garment is still, the color is amplified from the superimposing of the aligned imagery. When in motion, the images move independently, causing a visual blurring effect (see figure 1).



Figure 1. “Summer”. Digitally printed silk broadcloth and silk gauze; with digitally printed silk strip-knitted fabric.

More recent areas of exploration center on our desire to work with geometric shapes that can transition from two dimensions (2D) to three dimensions (3D), evolving through many iterations from flat to draped and, ultimately, to complete 3D apparel forms. These explore shapes and patterns that begin as flat geometric forms that “transform” into garments. They also are conceived to allow the imagery to flow with the shape but not correspond to any specific contour. When the shapes are combined with the printed digitally manipulated imagery, viewers are forced to spend time analyzing the intersections between image and form. They can be displayed flat or in numerous 3D variations. One recent piece, “Transformation: Overload,” was conceptualized for display as a 3D structure and then sequentially deconstructed until it becomes one large irregular 2D shape. It is printed on both sides, in inverted colors. At each point in the transformation, the garment takes on a new aesthetic iteration. While the piece can be viewed as a static shape in any of its ‘iterations’ of form, it is most effectively understood when observed in a time-lapsed video format as it transforms from completely flat to completely closed garment structure (see figures 2 and 3).

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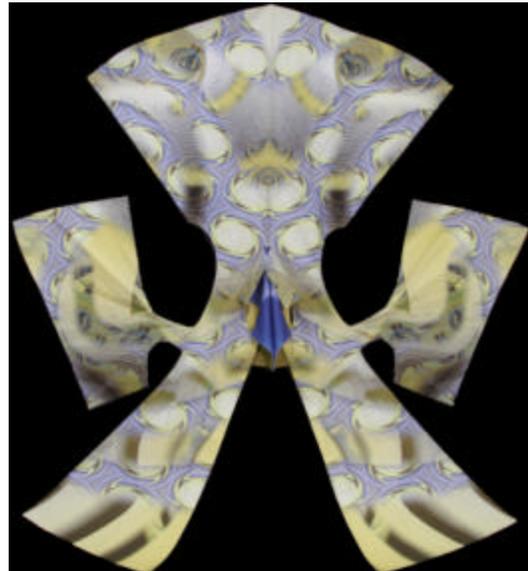


Figure 2. “Transformation: Overload.” Digitally printed cotton duck; shown in its flat (2D) state.



Figure 3. “Transformation: Overload.” Digitally printed cotton duck; shown in one of its 3D iterations.

As these pieces are developed we ask ourselves how we are going to approach and convey the standard garment concepts of front/back, inside/outside, top/bottom; or whether we need to convey these concepts at all. Figures 4 and 5 show “Transformation: Water/Fire”, an art piece that can be turned completely upside down and reconfigured for display on the wall or body. Our approach to the creative process evolved in response to the integration of technology.

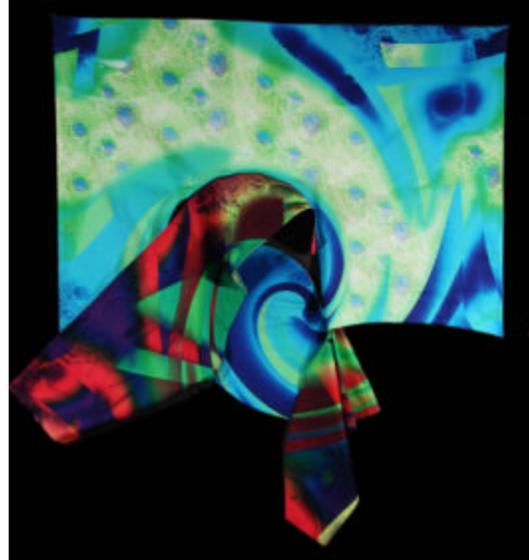


Figure 4. “Transformation: Water/Fire.” Digitally printed cotton sateen; shown in one of its possible 2D-3D iterations.

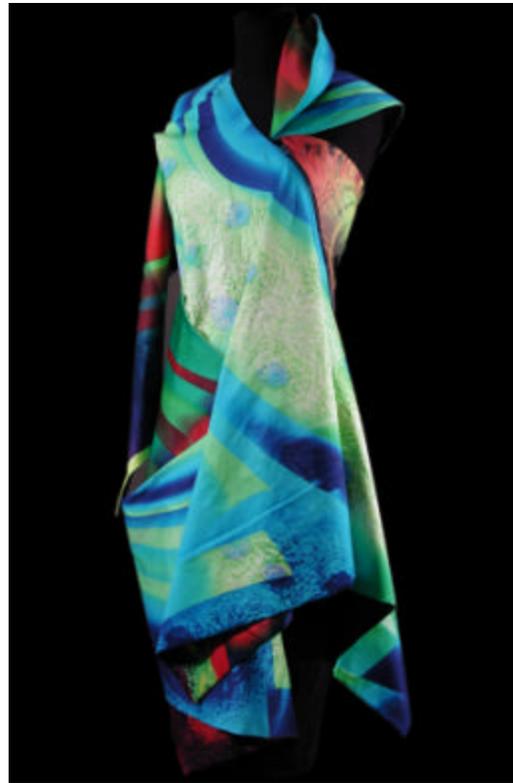


Figure 5. “Transformation: Water/Fire.” Digitally printed cotton sateen; shown in one of its variations on the dress form.

Custom Design

In 2001, we were commissioned to design and produce an Inaugural gown for Iowa First Lady Christie Vilsack. This gave us the opportunity to develop an approach for working with a customer on a project that allowed a merging of traditional pattern making and fitting with digital textile and apparel processes. The use of digital technologies for custom apparel businesses presents many opportunities and some challenges. This allowed for exploration of both.

The design process was begun in a customary manner, with preliminary sketches and a meeting with the customer. Her request was for a gown that would be uniquely an Iowa product. The decision was made to use images from a stained glass window in the governor's mansion. Using the initial sketches, and photos of the windows, a series of designs were created. Five original garment styles with thirty possible design variations, each with different color selections and imagery, were presented to the customer. While this seemed like a potentially overwhelming number of options, we wanted to have a range of choices available (see figures 6 and 7 for design variations).

After a design was chosen (see figure 8), the next steps returned to a traditional custom garment design approach, with measurements, pattern making and a muslin fitting. The pattern was then digitized into the PAD program and the imagery was manipulated and engineered to precisely fit the pattern shapes, to blend across seam lines and to provide the most flattering placement for the customer. Our previous research/design explorations into the integration of style pattern and print design (matching imagery across the seam lines) allowed us to concentrate on other creative and technical issues. Each previous art-to-wear piece began with a problem statement intended to allow exploration of the potential of the technology. This experience allowed a more practiced approach to this commission.

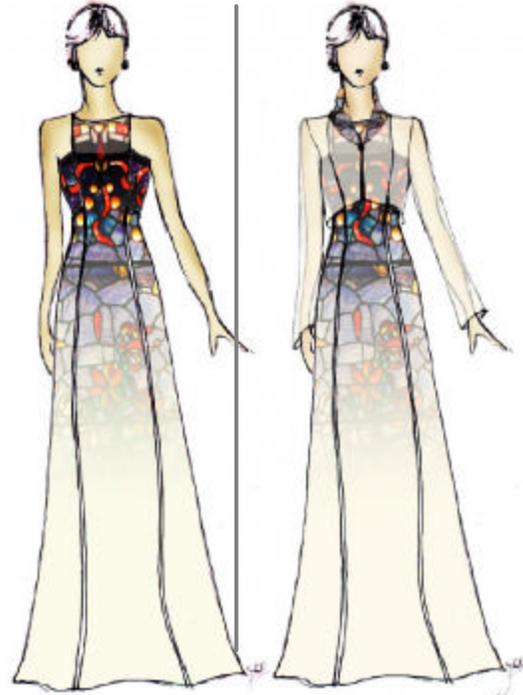


Figure 6. Examples of initial design ideas presented to the First Lady of Iowa.



Figure 7. Examples of initial design ideas presented to the First Lady of Iowa; the designs ranged from more traditional design lines and image placement to non-traditional structured and fitted garments.

The final design for the Inaugural dress required few alterations, and was considered a success by the customer (see figure 9).



Figure 8. Selected garment design for the Inaugural Ball Gown.



Figure 9. Final fitting of the Iowa First Lady's Inaugural Ball Gown.

One of the advantages of using digital printing and patternmaking technology is that if changes

are desired, whether for reasons of garment fit or for creative decisions, a new version can be redone on screen and the garment reprinted. With a custom fitted garment, and with images engineered to match at all major seams, there is little opportunity for alteration once the garment is printed. However, it would be possible in working with a custom designed product to keep the imagery simplified in several critical areas of fit. There are many advantages to this process for a custom business. With the fitted, digitized, pattern available, many other designs could be produced for the same customer with little extra time needed for fitting. The process could also be done from a distance. In addition, the design potential is unlimited. Customers could choose from a selection of already developed imagery or choose to have the surface design completely personalized.

Mass Customization

For the past two years we have been involved in leading a creative research project called "Digikids: Incorporating Digital Textile Printing into the Co-Design Process of Mass Customization of Apparel Products." For this research, the project collaborators created a series of digitally printed textile designs and children's garment prototypes for use in the co-design scenario. These were "marketed" through an original web interface. The research team assessed the online design interface to measure level of expectation and satisfaction of digitally printed mass-customizable children's wear. We then printed and produced a series of the customized garments with imagery selected by test group consumers so that we could get feedback on their perception of the finished garments, the wear-ability, and care issues. In addition, we monitored and recorded the design/production related issues of creating customized digitally printed apparel as they occurred.

The first phase of the research project focused on assessing a strategy for apparel manufacturers to use competitively in the global market. Combining mass customization with the co-design process allows manufacturers to mass-produce customized goods and to provide

customers the opportunity to individualize products. Some development of mass-customized apparel products exists, but very little has been studied in the application of digital printing technologies to customized apparel. We began by creating the hypothetical process for integrating digital printing technology into the co-design process. We initially attempted to partner with existing children's wear companies that currently market some of their product through an online interface. Our goal was to post a link to our experimental website from these children's wear websites and provide incentive to their customers to participate in our research by giving them discounts to purchase product from these websites in the future. Unfortunately, none of the companies we contacted and communicated with ultimately participated in the project. This was due primarily to resource issues relative to creating the appropriate links from their site to ours. The companies also had

concerns about the security and policies for creating any link that would lead customers away from their own site.

Instead, we solicited participants through a purchased sample list of people who had previously purchased clothing online. This group was supplemented with respondents obtained by using contacts from the research team and by sending emails announcing our website. The site design allowed for a potential of up to 756 different combinations of garment styles and design features. The participants were asked to complete a survey prior to, and after using the online interface to customize a garment. They were able to select specific garment styles and surface design features, then mix and combine the components to create their own customized garment. Figure 10 shows an example of the online visual interface for the customization process.

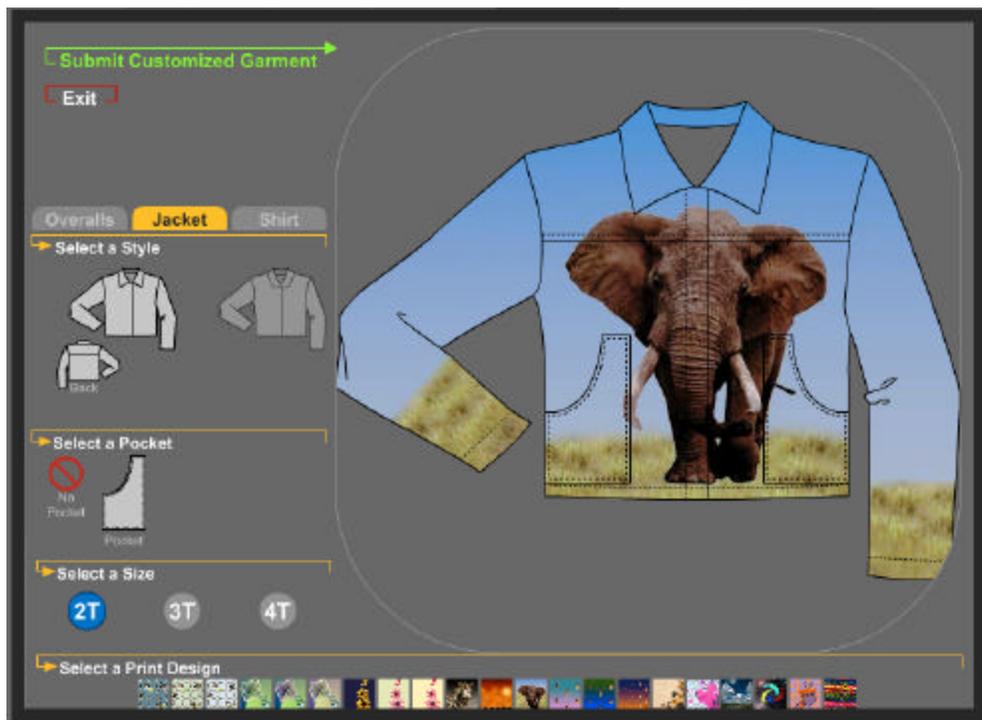


Figure 10. The visual interface for the “Digikids” online customization website.

We tested for expectation and satisfaction with regards to digital textile printing, the customization web site design/interface complexity, garment style choice, customizable

features, price range, timeline to complete customization online, and the timeline to receive a completed garment. Regarding the design

features of digitally printed children’s wear, we asked them to respond to their expectation for:

- Seeing a photorealistic effect
- Getting a unique print design
- Getting clear imagery
- Getting different kinds of printed imagery that they could not find elsewhere
- Building their own print design from image, color and motif on the garment
- Selecting from a number of print designs
- Designing the imagery for the garment themselves
- Getting a higher quality garment

- Ease in garment care

The data showed high expectation with regards to all of these elements with the highest rating going to the expectation to “get clear imagery.” Many, however, did not expect to be able to design the garment themselves. Nor did the participants expect to have to “pay more for the garment.”

After completing the online customization process, we asked the participants to respond to a few follow-up items related to the design features. See Table 1 for descriptive statistics on responses to the satisfaction for design features.

Please rate the following based on your evaluation of digitally printed clothing:					
A.	I was able to see a photo-realistic effect in the imagery on the garments				
B.	I think the customized garment prints available for “digikids” are unique				
C.	I think the imagery on the garment was clear				
D.	I liked the illustrations of the customized garments				
E.	I liked the way the images were placed into the garment shapes				
F.	I was able to visualize what the garment will really be like from looking at the garment illustration				
G.	The imagery choices worked well with the garment styles				
H.	The color choices available for the customized garment were appealing				
I.	I was able to get print designs that I can’t find anywhere else				
J.	I was able to select from a number of print designs				
K.	I was disappointed that I could not build my own print design.				
L.	I was disappointed that I was not able to design the imagery for the garment by myself				
M.	There were too many print design to choose from				
	N	Minimum	Maximum	Mean	Std. Deviation
A	207	1	5	3.84	1.216
B	204	1	5	3.79	1.086
C	207	1	5	3.93	1.108
D	206	1	5	3.60	1.192
E	206	1	5	3.67	1.217
F	206	1	5	3.90	1.132
G	205	1	5	3.36	1.148
H	206	1	5	3.26	1.081
I	205	1	5	3.69	1.066
J	205	1	5	3.89	.984
K	203	1	5	3.15	1.283
L	206	1	5	3.11	1.256
M	204	1	5	1.80	.867

Table 1. Ratings of performance/satisfaction after respondents completed the Digikids customization website (1 to 5 scale)

Overall, in a breakdown of ratings, the participants first expected the process to be fun. Then they wanted to be able to select the garment color and fabric print that they would like, followed by being able to choose a unique style, and then to be able to select the best fit. This has some interesting implications for both the designing and marketing of digitally printed customized clothing. Through their garment choices we found that the participants tended to prefer the more accessible imagery with recognizable motifs. They also more commonly chose the t-shirt concept over the jacket or overall options. Of the thirteen print designs that we provided as options, a flower design was chosen most commonly, but all thirteen print designs were selected by at least one participant. The strongest message related to the level of satisfaction about the number of print designs from which they could choose. We received a very low rating on this item, which suggests that consumers might want an even larger number of print design options to select from during the customization process.

Once the data was collected and interpreted from the website, our collaborative team produced a selection of the garments chosen. Figure 11 shows the layout for the file that was printed directly to fabric for the “Elephant” jacket option. The entire process, beginning with participant interaction with the web interface through to completed garment, was then evaluated to 1) assess the level of visualization required for customers to feel comfortable making the decisions necessary to purchase a customized garment and 2) the success of the final garment. Figure 12 shows an example of one of the finished garment designs.

The Digikids research project has broad reaching implications in the fields of apparel design and manufacturing, including potential to facilitate adoption of mass customization by small business retailers/manufacturers as they strive to meet the need of consumers in a rapidly changing retail environment. The design potentials of digital textile printing are perfectly suited for the creation of innovative and unique mass customizable garments that can be sold

through an online interface. Through the process, it became very clear that effective file management is a key to success and that diligent color management is a necessity.

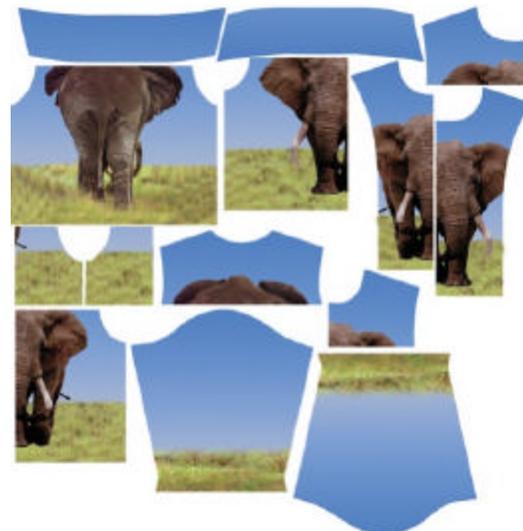


Figure 11. Example of the print layout file that was generated for the elephant jacket.



Figure 12. Example of a “Digikids” overall/romper finished garment.

Conclusions

One of the most important aspects of research in the design field includes not only the creative work itself, but also the exploration of new methodologies and design processes. Designing with new technologies can open up a constantly expanding range of creative possibilities and generate a more complex set of decision points for designers. These changes in design production methods and in future products need to be addressed by both design researchers and practicing designers. The potential impact is on

designers of art-to-wear as well as on apparel industry designers and manufacturers. The body of research and artwork that we have developed suggests that a systematic approach to integrating new technologies into the textile and apparel design process can be developed, recorded and employed in future design explorations to inspire the most rapid technology integration with the greatest potential for new product conceptualization.

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