DYNAMIC PATTERN CREATES INTERACTIVE FASHION

The Potential for a Mobile-controlled Dynamic Pattern

to Create an Interactive Fashion Brand

A Business Plan

By

Yutong Han

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ABSTRACT

In recent years, the fashion industry has started to focus on user communication and behavior moving towards a promising future of integrating wearable technology into a wave of new fashion design. The fashion industry plays an important role in the adoption rates of wearable technology. They bring brand recognition, design aesthetics and expertise in wearability and fit to the field. Many start-ups fashion firms incorporate wearables in their products or business plans.

This thesis uses user-centered approach for designing interactive garments that bring interactive functions, communication and entertainment to the user. It also creates a business plan for the interactive fashion brand. In so doing, the thesis aims to create an effective design and business method for successfully bringing an interactive fashion brand to the mass market.

KEY WORDS

Dynamic Pattern, Wearable, Fashion, Smart Textile, Thermochromic Pigment, Heating Fabric in Fashion, Mobile interaction, Interactive Fashion, User-centered Design, Start Up Fashion Brand.

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INTRODUCTION

This is the era of emerging technology within the fashion industry. In the last few years the fashion industry has seen more and more promising trends in wearable technology. Mattias Lewren, global managing director of Accenture's Electronics and High-Tech Industry Group, has stated, "Companies should consider investing in wearable product innovation and building ecosystems that connect wearables to the broader array of interactive digital networks."(Wright, 2015). Fashion designers are utilizing a greater number of wearable technologies. This is backed up by a new generation of textile designers that are finding inspiration in technological systems while significantly enhancing the user's experience that reflects on the garment (Quinn, 2013, p.7). This trend is already demonstrating considerable market value with the wearable electronics industry valued at US$20 billion in 2015 and expected to rise to US$70 billion in 2025 (Harrop, 2015).

As wearable technology rapidly becomes more common in our daily lives, mobile wearable communication is becoming a new communication paradigm (Moustafa, 2015). Differing from sensor based wearable products, mobile communication brings various

opportunities which allow devices to communicate to create peer-to-peer fashion or client-server fashion (Moustafa, 2015). Mobile device can provide the input interface for interactions and play the role for connection with other users or servers. The convergence of mobile and wearable technology provides a more diverse interaction pattern between users and wearable devices. By understanding some of the ways in which fashion has already integrated technology, we can gain insight into how electronic technology may create divergent products from previous developments (Genova, 2016, p.4).

In this body of research I am proposing a design and business method for creating a fashion brand that can interact with a mobile device and bring entertainment, communication, aesthetics and other functionality to consumers, in an effort to maximize the adoption of wearable fashion in the mass market.

In order to achieve this goal, this thesis uses a user-centered design method in the design process to ensure that the product provides the best functionality and user experience for users. Once the garment is integrated with electronically operated functions, it surpasses the functions found in a traditional garment. Since the power of design is difficult to measure on a scale, research helps the designer to develop

and support their concepts as well as measuring the effectiveness of a finished project and supporting a design hypothesis. It can also help in finding effective solutions to problems (O'Grady, 2009, p.10). From sketching to pattern making and textile development, the use of multimedia software and various technologies has impacted the process of clothing creation. As these innovative tools change the process of fashion design, traditional production methods also have to adapt (Genova, 2016, p.4). This thesis seeks to develop a research-based method for creating an interactive fashion garment that more fully satisfies its consumers' needs and interests. At the same time, the garment optimizes its user experience by revising its design and functions to meet needs determined by user research results.

Besides function and interaction, another major factor affecting garment design is fabric. Material innovation is an important consideration in development of interactive fashion garments. The development of new materials has always been an important influence on fashion. New materials suggest new aesthetic possibilities for designers. As available materials change, designers adapt accordingly (Genova, 2016, p.7). Smart textiles bring various possibilities for the

fields of health, biology and fashion. Research in this body of work considers the consumers' concerns, attitudes and acceptance of new technologies that includes wearable technology itself, aesthetics, material selection and pattern design assessing their value in shaping the final product.

This thesis compares different materials for wearable garments. The comparison data uses the cheapest and most feasible material to keep down the cost of the garment and maximize the entertainment, communication, aesthetics and interaction functions. The research data supports the design and technology used on the garment. It provides the basis for product development, thereby impacting the success of the brand. The research and design process creates a different method that is special for the interactive fashion brand rather than a common garment design process.

Research Method

Why is research so critical in wearable fashion design? Although wearable technology has been around for many years, it is only in its infancy in making it appealing to consumers. To make a marketing breakthrough, significant investment in research and development is required, because success in wearable markets will only be achieved if

a company continually places consumers' needs first. By understanding its users and putting research data accuracy and device stability into the overall experience, a company can successfully create beautiful, intuitive products that consumers will want to buy (Wright, 2015).

The research method that I use is user-centered design and survey. User-centered design creates powerful tools for understanding people and creating designs that work. These methods have helped designers explore the context for inspirations. (Koskinen, 2011, p.18). Therefore, this business plan uses the user-centered design method as a guide for its design decisions. It tests the interactions between a garment and users to gather feedback on the product in order to understand the interactions that took place during user experiences. It also conducts a survey that aims to determine the targeted demographics for our product, learning about their financial means and also about concerns they have regarding a wearable garment that will help to define the features of the product.

THE MARKET

Current Market

We are now at a crossroads where the boundaries between apparel brands and digital platforms are blurring. Consumer wearables technology products provide a bridge between these two worlds, which is the catalyst for this convergence (Bertone, 2013). There is a big medical demand for accurate biological data sending from sensors and Internet of Things built in the wearable product. This will prove to be an important area of market growth for wearable technology in the next decade. As one of the important components of wearable products, clothes occupy a certain portion of the market share. Differing from wrist wear, which has the greatest market share in the wearable market, clothing has the most potential for growth, increasing from 0.0 point of market share to 4.5% of market share on 2019.

Worldwide Wearable Device Shipments, Market Share and Year-Over-Year Growth by Product, 2014-2019 (Units in Millions)

Product Category	2014 Shipment Volumes	2014 Market Share	2015 Shipment Volumes*	2015 Market Share*	2019 Shipment Volumes*	2019 Market Share*
Wristwear	17.7	90.40%	40.7	89.20%	101.4	80.40%
Modular	1.6	8.30%	2.6	5.70%	6.7	5.30%
Clothing	0	0.10%	0.2	0.40%	5.6	4.50%
Eyewear	0.1	0.30%	1	2.20%	4.5	3.50%
Earwear	0	0.00%	0.1	0.10%	0.6	0.50%
Other	0.2	0.90%	1.1	2.40%	7.3	5.80%
TOTAL	19.6	100.00%	45.7	100.00%	126.1	100.00%

Table 1: IDC Worldwide Quarterly Wearable Device Tracker, March 30,2015. Reprinted from *IDC*, n.d., Retrieved March 21, 2016, from http://www.idc.com/getdoc.jsp?containerId=prUS25519615

Accompanying the growing enthusiasm of the wearable market, the fashion industry has moved a step closer to the wearable industry. At the same time, technology and fashion have begun to merge with each other as seen in many fashion brands. By utilizing recent technologies many brands are producing new products that combine technology with aesthetics and wearability. Successful examples of this phenomenon include: the wearables maker Misfit which has teamed up with Swarovski to produce the "Shine", a series of fitness trackers in jewelry appearance; the Martian created "Guess Connect", a fashion Guess watch that shows caller ID and other information connected with mobile applications which can interact with Siri or Google Voice commands via an inbuilt microphone; Diane Von Furstenberg redesigned frame look for

Google Glass which makes frame design Google glass much more accessible for women.

Figure 1: Martian Created Fashion Guess Watch "Guess Connect". Guess Connect Powered by Martian in *Martian Official Website*, n.d., Retrieved March 21, 2016, from https://www.martianwatches.com/guess-connect/

Although clothing has not been as successful as accessories in the technology marketplace, it still has its advantages and potential. Clothing is the most human and common form worn across cultures and throughout a lifetime. Clothing also covers the body's surface area and is more versatile in its structure than other media, allowing better access and precision in the measurement of biological functions (Bertone, 2013). Reflection about wearable fashion serves a more philosophical function than commercial fashion interaction. It indicates the way that the experience of clothing reflects on the nature

of the material body apace (Bartlett, 2013, p.181). By adding the extra value to the garment, it allows various data reflects on garment, or even makes the garment interactive with the environment or social networks, which may attract youth as consumers.

As COM (set up by Adobe) reported in "*15 Mind-blowing Stats About Wearable Technology*" (Giselle, 2014), 48 percent of wearable consumers are between the ages of 18 and 34. Men and women show an equal interest in sport wearable tech. Twenty-nine percent of wearable owners earn over US$100,000 per year, whereas fifty-five percent of consumers consider wearable technology too expensive to purchase. According to the reports, there is currently a gap in the market for young consumers wishing to purchase a reasonably priced wearable product. If the fashion brand correctly targets main consumer groups, and provides reasonably middle priced products for its consumers, there is an opportunity to fill this void.

In summary, this is an ideal time to create an interactive fashion brand aimed at the mass-market rather than high fashion. There are many reasons. First, wearable technology is becoming more common in people's lives on a daily basis. Second, unlike other devices, the

garment has another advantage in that it can directly reflect information on apparel and obtain biological data from the body. Third, the market gap for reasonably priced wearable fashion for young people provides a very rare opportunity in upcoming years. Forth, as technology and fashion converge, this will create greater market awareness and accessibility increasing consumer interest and demand for wearable technology.

Future Growth

The wearables market maintained its upward trajectory in the first quarter of 2015 as new vendors, including Apple and Google, prepared to enter the market. The International Data Corporation (IDC) Worldwide Quarterly Wearable Device Tracker estimates that shipment volumes of wearable technology are expected to experience a compound annual growth rate (CAGR) of 42.6% to reach 155.7 million units by 2019. "The demand for basic wearables, those that do not run third party apps, has been absolutely astounding," said Jitesh Ubrani, senior research analyst at Worldwide Mobile Device Trackers. "Vendors like Fitbit and Xiaomi have helped propel the market with their sub-$100 bands, and IDC expects this momentum will continue throughout 2015"(Figure 2-3). A recent study by Forbes illustrates

promising returns indicating that revenues from wearable technology will reach $20 billion by 2017 (Sabhlok, 2013). Credit Suisse predicts that in three to five years £18-30 billion a year will be spent on wearables (Arlidge, 2014).

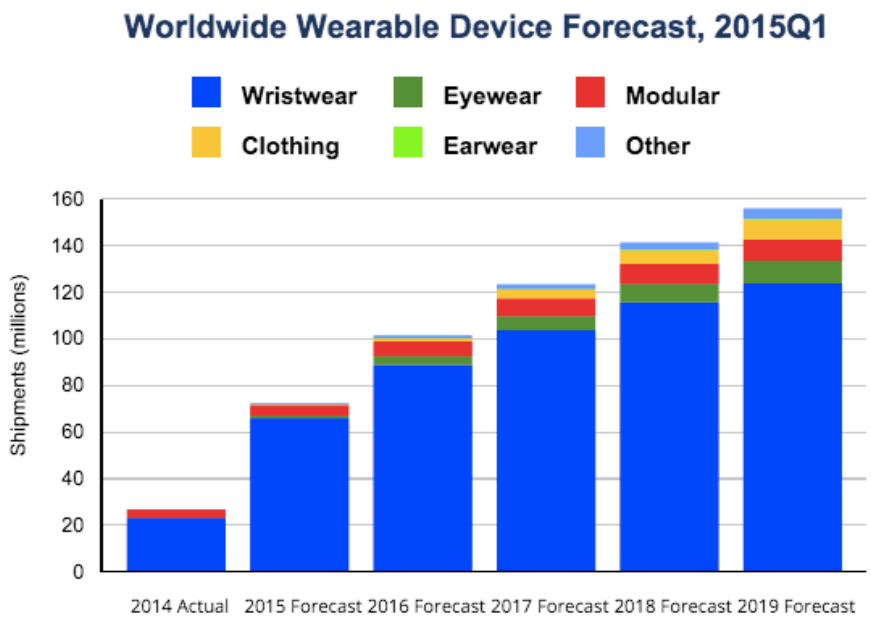

Figure 2: Wearable Market Forecast to Grow 173% in 2015 with 72.1 Million Units to be Shipped According to IDC. Reprinted from *IDC*, n.d., Retrieved March 21, 2016 from http://www.idc.com/getdoc.jsp?containerId=prUS25696715

Currently textiles comprise more than 90% of our daily life contacts and they are evolving into intelligent materials enabling the integration of electronics to bring new types of functions into our lives. Key advances in textiles during the last five years have led to early commercial products, with a market of around $100m in 2015. New products integrating e-textiles are being created. The market has been

slow to get off the ground due to many challenges, but with large companies investing heavily and releasing innovative products, we expect the growth to accelerate rapidly over the next decade. As larger names enter the marketplace and the significant investments start to show returns, IDTechEx forecasts that the textile market will reach over $3bn by 2026 (Hayward, 2015).

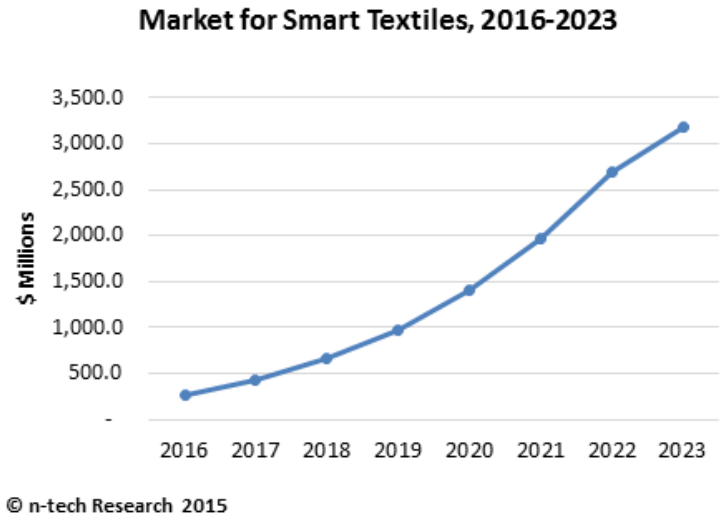

Figure 3: Smart Textile Market 2016-2023 Reprinted from *Smart Textile Market 2016-2023*, n.d., Retrieve March 21, 2016, from http://ntechresearch.com/market_reports/smart-textiles-markets-2016-2023

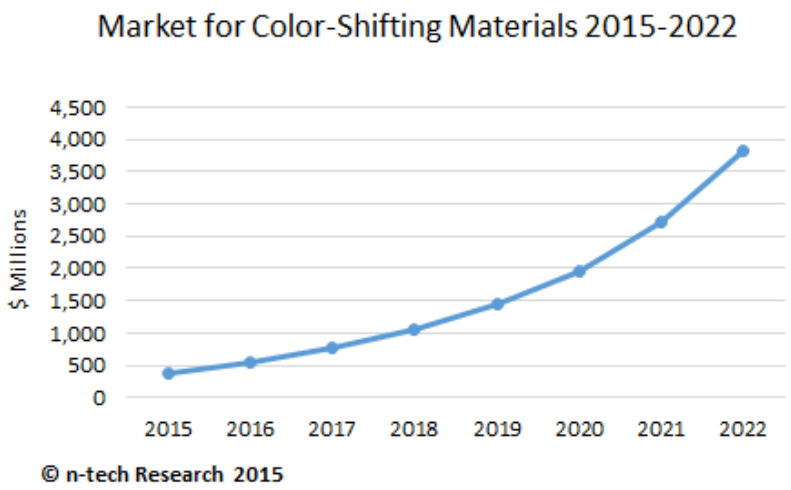

Figure 4: Color-shifting Material Market 2015-2022. Reprinted from *Color-Shifting Material Market Opportunities -2015 to 2022*, n.d., Retrieve March 21, 2016 from http://ntechresearch.com/market_reports/color-shifting-materials-market-opportunities-2015-to-2022

The current trends show that the fashion industry is evolving with the technology industry. Fashion brands are trying to break down the barriers which keep wearable technology from making greater inroads into the mass market. The popularity of the Apple watch is one of the best examples. The success of our product will present another new form of garment for venturing into the emerging mass market. It will be a new form of fashion brand in the mass market, representing interactive fashion styles. But it requires us to act fast. If we are too slow in acting, competing brands and start-ups will launch products first and the uniqueness will be lost.

Competitors

Cute Circuit

Since Cute Circuit is one of the most successful interactive fashion brands, it can be used as the best model for interactive fashion garments. It is a very strong competitor in the fashion industry. Cute Circuit first launched in 2004. It is located in London, and the garments are designed by owners and designers Francesca Rosella and Ryan Genz. Their approach uses many ways of achieving high-end fashion results. They utilize innovative materials, electronics and prints to create stunning high-end fashion garments. Their consumers are those who purchase high-end fashion and its business module is haute couture and online sales. In 2013 they designed a number of haute couture LED light decorated dresses for Katy Perry. They now have a range of technology-enhanced dresses available for sale online. The average price is around £300.00. They also have a K-Dress series available commercially, based on the dress Katy Perry wore at the MET Gala New York in 2010. The dress retails at £1,500.00 (Dalsgaard,2014). It shows that Cute Circuit targets the consumers who need to have special events or parties. They are not aimed at the mass market based on a price that is unaffordable for these consumers.

THEUNSEEN

THEUNSEEN is an example of how much the intersection of design, fashion and technology is growing. THEUNSEEN is an exploration house that blends biological and chemical matters into materials. It is led by material alchemist Lauren Bowker. Differing from Cute Circuit, THEUNSEEN only sells accessories, decorations and bags in its online store. Its company targets art and trade exhibitions that integrate technology with fashion products. According to its product design, the targeted consumers for THEUNSEEN are those interested in the arts and who like to use accessories to express their tastes, styles and personality.

The price range of THEUNSEEN is from $5 to $1,750. Although it has very cheap products, its bags and scarves can be as expensive as approximately $1,800. Unlike Cute Circuit, THEUNSEEN targets the middle class fashion market and it does not sell garments. It walks the art concept route. It displays at exhibitions and holds workshops and press events. The opportunity for our company lies in producing colour-shifting garments for consumers, whereas THEUNSEEN only produces bags and accessories.

Figure 5: Color Changing Bag Designed by THEUNSEEN, Reprinted from *THEUNSEEN*, n.d., Retrieved March 21, 2016 from http://theunseenemporium.co.uk/

Maggie Orth

Maggie Orth is an American artist and technologist who helped to develop the E-textile field. Her 2001 MIT Media Lab PhD thesis, sculpted computational objects with smart and active computing materials and associated publications and patents, are among the early work in this field. She currently focuses on two types of electronic textiles, namely programmable colour-changing textiles and touch sensitive textiles with light. Comparing with my work, Orth's work is more functionally oriented and academic and exhibitions and events are the main public experiences. There are two differences between my thesis's product and Orth's work. First, my product involves colour-changing textiles on garments, whereas Orth's work involves

textiles only. Secondly, my product uses mobile control and integrates with Big Data and social networking, whereas Orth's works are usually controlled by software. Orth focus her works from paintings to weaving. This is an evolving trend that my product may follow in the future.

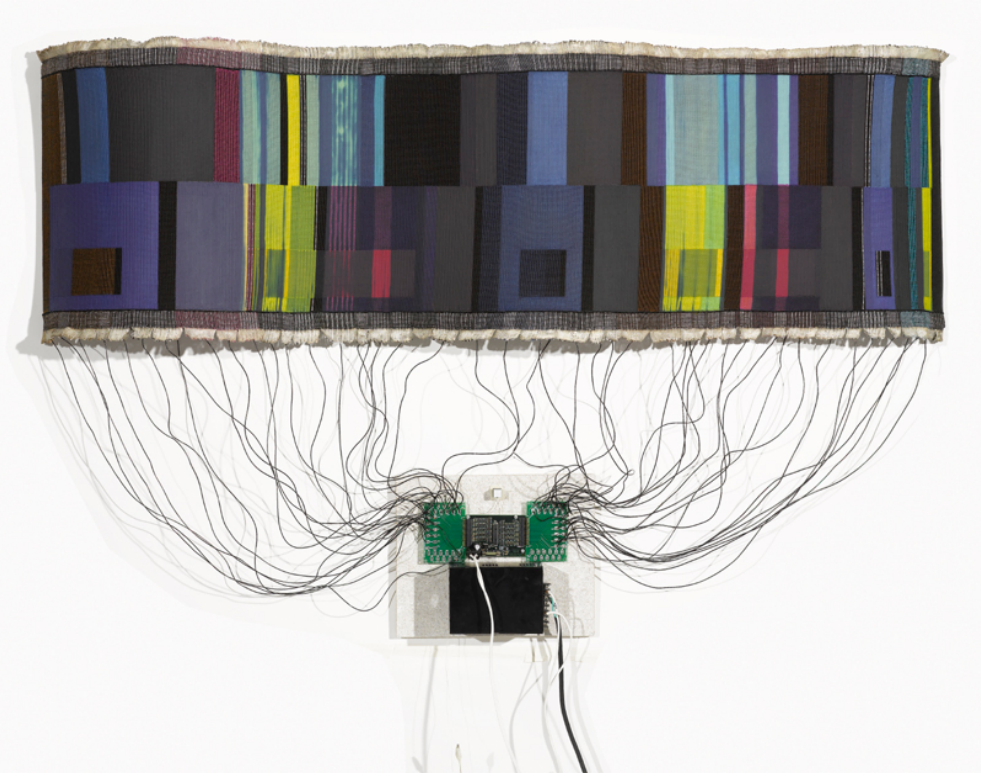

Figure 6: Maggie Orth Hand-woven Project of 100 Electronic Art Years 2009. Reprinted from *100 Electronic Art Years, 2009,* by M. Orth, Retrieved March 21, 2016, from http://www.maggieorth.com/art_100EAYears.html

Project Jacquard

Project Jacquard, which is supported by Google, makes it possible to weave touch and gesture interactivity into any textile using stand alone industrial looms. It allows everyday objects to be transformed into

interactive surfaces. The project Jacquard products are cost-efficient to produce, and the functional yarns and fabrics can be manufactured with standard equipment used in mills around the world. The Jacquard loom can generate as many different textile designs as needed to meet demand. The same loom can now also weave in interactivity. The main business mode is to provide textiles and technologies for smart textiles. It allows designers and developers to build connected, touch-sensitive textiles into their own products.

AN INTERACTIVE FASHION BRAND

> *"The successful expansion of the smart textile market will also rely on more collaborations in order to create products that are not mere novelties, as was the case with the first generation of smart clothing, but meet consumer needs and provide function and value that will compel enough people to buy them. The latest generation of smart textiles might benefit from 'fashion'—in this case the current fashion for creating business 'ecosystems,' is an important part of strategy."* (N-tech Research Report, 2015)

Company Mission

Our company mission is to set up the new fashion brand DView (Dynamic View). The brand is inspired by its product features and aims to bring dynamic views on garment for everyday wear. This brand provides low cost, high quality wearable fashion garments with functions that enable mobile control of dynamic patterns, bringing

smart textiles into the fashion field. Its functions allow its users to change the patterns on garments to suit different situations or occasions instead of changing their garments. The product targets the younger generation, which provides the greatest potential for the marketing of interactive garments. This invention aims to create a lightweight, comfortable, washable and safe garment for the mass consumer market. Such garments will consider that clothes are social symbols allowing members of the younger generation to express their culture, values and emotions. DView aims to integrate low tech and high tech in fashion design to bring new functions, entertainment and social connections to fashion garments.

Short-term goal: Refine the design and set up the brand. The launch of the first series of garments with online sales.

Long-term goal: Become a pioneer fast-fashion brand in North America and China, which stands out by the interactions on fashion garments.

SWOT of DView product

Strength	Weakness
Integrate technology and fashion design that creates the stylish interactive fashion garment.	Lack the experience of putting interactive garments into market.
Opportunity	**Threats**
The market is growing fast and consumers have great interest in this field	Other fashion brands are trying to work on interactive designs

Table 2: DView SWOT analysis

Users

Using “good value for money” as a key strategy and developing a “middle price” wearable garment, the target consumers will be college students and entrance level young female professionals who are keen on using new wearable technology. An attractive point to market is “Your first wearable fashion garment will make you the focal point at school or the office."

“The generations and the gap between them play a very vital role." Says in Jamal's *Analysis of fashion product of appeals from*

Consumer lifestyle perspectives. He mentions that youth will prefer clothes as per fashion trend and 25-35 age range will prefer clothes which are "netrual", and older consumers prefer to follow the trend that they are most comfortable in (Jamal, 2013). DView target group focuses on the young female consumers who are university students and young female professional under 35 as its primary consumers, and 35 and above fashion forward consumers as its secondary target user group.

Target Consumer Segment (Decided by user research result)

Key	Second
18-35 females, students or young female professionals	Above 35, fashion forward consumers

Table 3: Target Consumer Segment

Demographics

University Students

This user group is between the ages of 18 and 24. They are new technology fans wanting to distinguish themselves from others. They want to buy clothing that will express their styles and they read blogs

about wearable fashion, but garments are either not for sale or are too expensive; they love the interactions on garments, but some interactive T-shirts are not stylish or fashionable; they desire a comfortable, washable and cheap interactive garment.

Young Female Professionals

This user group is aged 22 to 35. They are interested in new technologies and are fashion fans. They need fashion garments in their daily work to make them look more professional. After work, they may go shopping or to parties but usually they don't have enough time to change their clothes. They need a garment which is fashionable in different scenarios.

Fashion forward consumers

This user group is 35 above who are Fashion Forward and identified as those that like to be at the forefront of new fashion trends.

Meeting Consumer Needs

The garment maximizes the engagement of interactions with fashion. It has an online store which makes the purchase process easy and it is reasonably priced. The garment not only enhances interaction; it also enhances design. It allows the users to change its pattern according to

different scenarios in less than 1 minute. The garment is as soft and comfortable as an every-day garment as well as one that can be worn on special occasions.

Similar brands are priced at around US$1,500-US$3,000 and they target the high-end fashion market. But high-end fashion consumers are not the key consumers for wearable fashion garments. Our DView fashion garment ranges in price from around US$150 to US$400, which is affordable to most consumers in the targeted market.

DView FASHION GARMENT

We create a fashion design garment with added interactions that enable mobile application control of the dynamic pattern on the garment. This creates a new wearable interaction and social interaction feasibility.

How does it work?

The pattern of the garment is well designed and printed onto the fabric with colour-shifting ink. The garment includes a circuit piece that is removable when the item is being washed. It has a power button that enables users to decide whether or not they want the garment to

receive a mobile command. While the garment is in the active status, users can change the pattern and colour with the mobile application, which is designed for this garment. The controller is a web-based cross platform application. It has IOS, Android, web and WAP versions. The garment and mobile uses Bluetooth to communicate, so there are no extra Internet charges.

The design allows for the functions to be upgraded addressing the issue of a fast changing area of technological development. Users' friends or families can change the pattern. Some upgrading is required for functions on mobile applications and it will be one of the further steps involved in designing the garment.

Figure 7: Product Sample - The Prototype for the Thesis

Product Features

The garment is as soft as other common clothes and there are no

uncomfortable parts. The whole circuit is created using conductive thread and a electricity heated fabric. The garment feels extremely comfortable, which is different from other electrical decorated garments. The garment is washable and very low maintenance. Furthermore, it has a reasonable price.

Product Functions

The product will have some basic functions when it first launches and more functions can be added according to different users' needs.

Basic Functions

- Mobile control colours on garment (prototype 3 in this thesis).
- Mobile control patterns on garment (prototype 2 in this thesis).

Future Added Functions

Bradley Quinn mentions in his *Fashion Futures* that "Future fashion will reflect social network, blogs, and GPS-enabled forums on our garment. A virtual platform experience will be brought to our real-life through wearable technology" (Quinn, 2012, p.6). There are some other future functions that are added to our product that take full advantage of mobile communication features.

- Users' friends or family use their device to control the user's colours/pattern on garment surface. This function uses the cloud technology on servers that synchronize the command for remote users.
- Environmental data control colours/patterns on the garment surface.
- Body Biological data control colours/pattern on the garment surface.
- Social Net Work data control colours/pattern on the garment surface.

Product Innovations

The startup produces interactive fashion garments for mass markets that have yet to be successfully launched by any fashion brand. The garments have their own advantages to drive their success in the mass market because they solve the problems that have limited the adoption of wearable fashion by the mass market.

Problems

1. Interaction garments are hard to accept by the mass market because of comfort, safety and stability.

2. Fine looking is a critical factor in garment design and this is a key factor for functionality garments.

3. High price is a barrier for most potential consumers seeking to buy the garment.

4. No successful wearable fashion garment product is currently designed specifically for the mass market.

5. Social functions are not successfully built into any fashion garment products in the market.

Solution

DView offers a viable alternative to traditional LEDs instead adopting the concept of a dynamic pattern based on thermochromic inks applied to the textile surface. The textile surface is a layer beyond aesthetics and identity. It is a medium for communicating with the environment. Surfaces are also manifestations of social norms and moral codes. They enhance the styles and fleeting interactions (Quinn, 2010, p.61). We use thermochromic pigments to design a lightweight, comfortable, washable, safe and reasonably priced garment, which allows smart textiles to interact with social networks and even environmental or other types of Big Data in a fashion form. The trend is

also mentioned in Quinn's book *Wearable Fashion* that states that wearable technology will enable the sense of garment communicating with the environment to play a greater role in everyday experiences (Quinn, 2012, p6).

DView has been developed after conducting detailed research into its consumer and user behaviours. It tests and evolves different materials while aiming to break through the barriers blocking the creating of marketable digital functional fashion garments. The design process employs user experience design techniques such as a user-centered design and survey. All of these efforts aim to ensure that this invention is well suited for mass market adoption.

DESIGN PROCESS

To render the product ready for success on the market, conducting research to deeply understand users' needs and select the appropriate material and technology to shape the design becomes critical. Therefore, I conducted surveys to determine the concerns people have about wearable fashion garments. Then I researched various potential materials and material companies, and the technology solutions for the interaction functions. Following that research, I tested the material with the circuit and chip board, which is selected form material and

technology research. Using the combination of the material and circuit, I built three prototypes in order based on the feedback and user testing results of the previous prototype. This design process is based on a user-centered philosophy to evolve the design, shape the final design decision and develop future evolution directions.

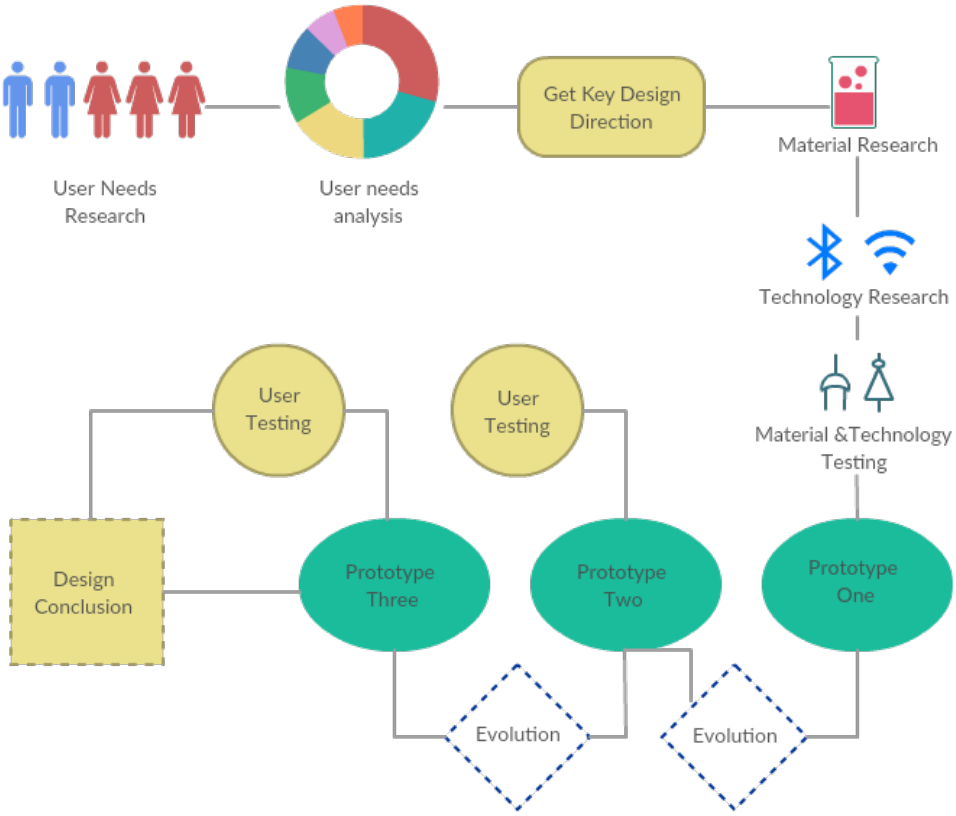

Figure 8: Design and Evolution Process of the Garment

User Needs Collection

Surveys help designers to gain insights into the opinions and desires of their target audience. The survey results can assist designers in making decisions during the project developing process. They can also

be used to support or confirm creative solutions (O'Grady, 2009, p.48). Therefore, I decided to conduct a survey to learn more about my target audience and decide what materials and technologies could be used in my product. I began by sampling those who were most likely to use the product. Participants included students, designers, architects, information designers and programmers, among others. The first round of using the questionnaire was geared toward screening for problems in the questions and narrowing down the potential users of the product.

The questions covered respondents' age, education, gender, occupation, financial abilities, attitudes on buying fashion garments, attitudes toward wearable fashion and their concerns about wearable garments. The questionnaire included 10 questions. Besides demographics, it also investigated the key factors encouraging consumers to buy a wearable interactive garment, the key concerns for consumers wishing to wear an interactive garment and affordability for consumers seeking to buy an interactive garment. (Appendix D)

User Research Analytics

To analyze the data, I separated the data by gender and age. In the gender category, I compared data between males and females to see which gender is more interested in a wearable fashion garment.

In the male group, there were eight respondents, all of whom had an education above a bachelors degree, and ranged in ages from 26 to 37. Most of them were masters students. From the research data, it was clear that design was the most important factor for them in buying a garment. Cost was the second factor. Fashion designer and brand did not affect their shopping decisions. (Figure 9) The research results reveal that these people were familiar with new wearable fashion and more than half of the male respondents would like to try it. (Figure 10) (Figure 11) Another key factor is price. Most male respondents could afford prices lower than $150 for buying an interactive garment but no respondent could afford a price higher than $700. (Figure 12)

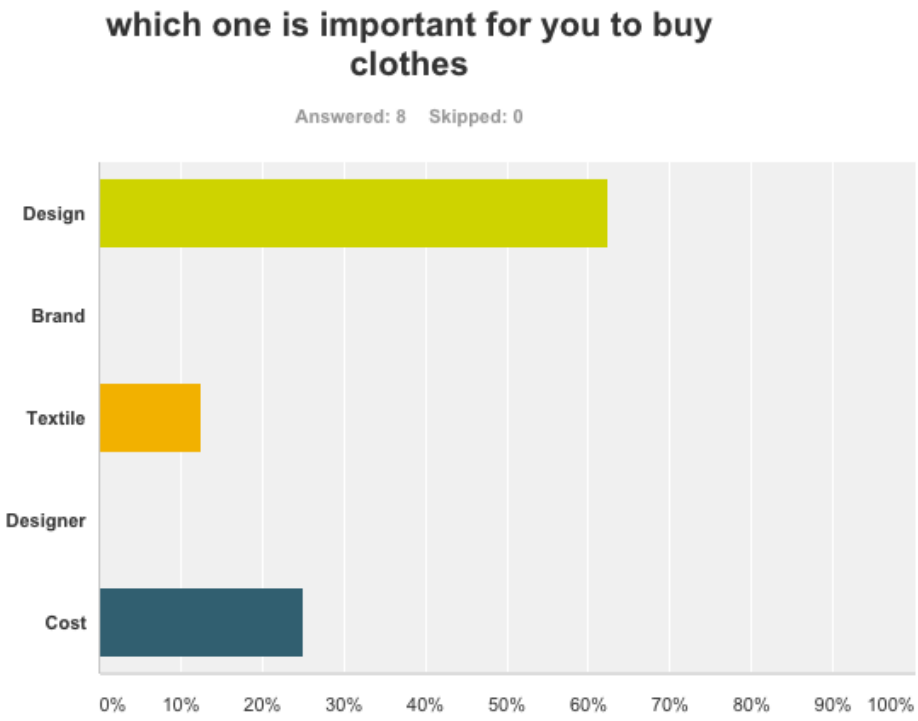

Figure 9: User Research Data Result

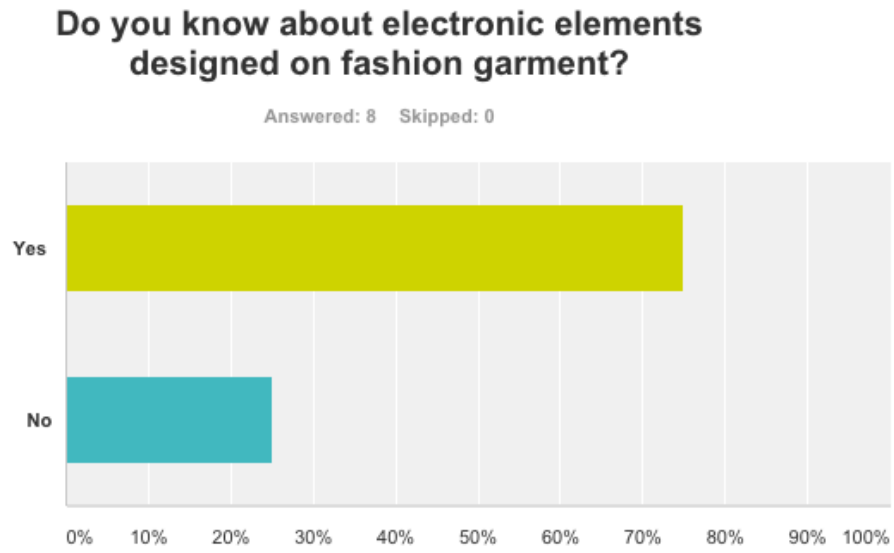

Figure 10: User Research Data Result

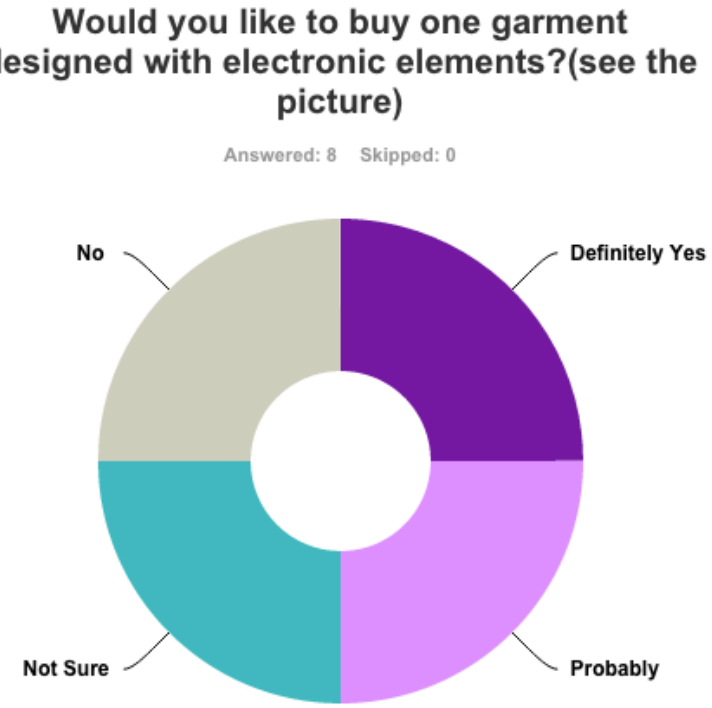

Figure 11: User Research Data Result

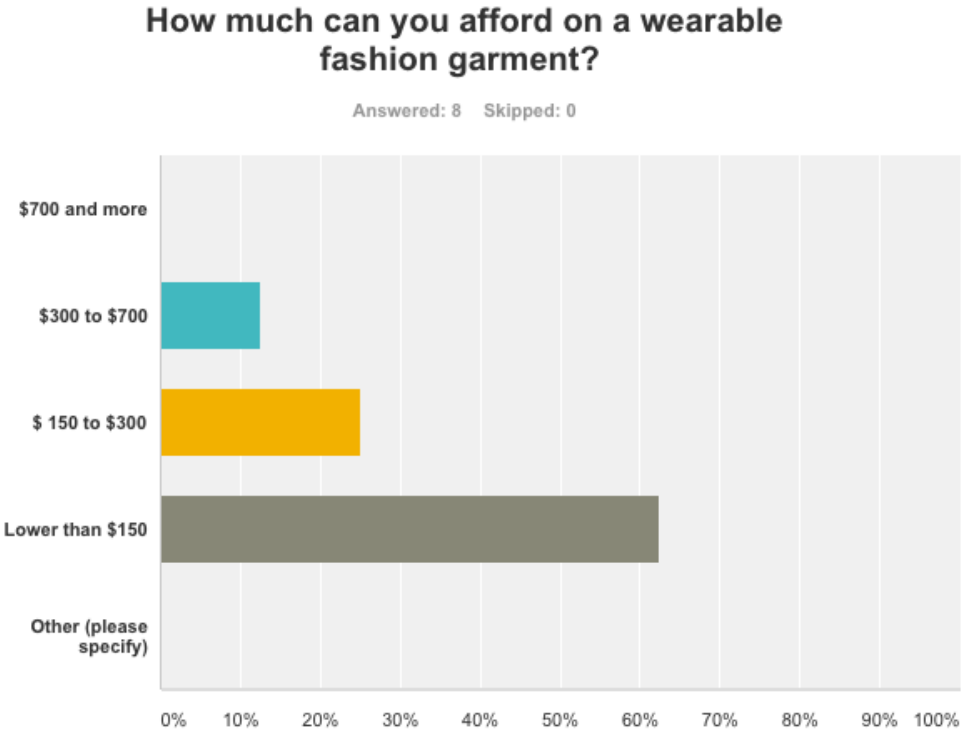

Figure 12: User Research Data Result

There are 10 respondents in the female group. Differing from the male group, the respondents' ages go up to age 59. Three respondents were above age 40, specifically ages 42, 51 and 59. The data from this age group provides different views towards wearable fashion. First, we see the female group in which 90% of the respondents have above a bachelor degree. The participants include students, an industrial designer, a graphic designer, an artist and a self-employed life coach. This group provides more versatile data for analyzing.

On factors influencing whether or not to buy a garment, the female group surprisingly gave the same result as the male group. 70% of respondents chose design. Cost and textile play a minor role in importance, and no respondents chose brand and designer. (Figure 13)

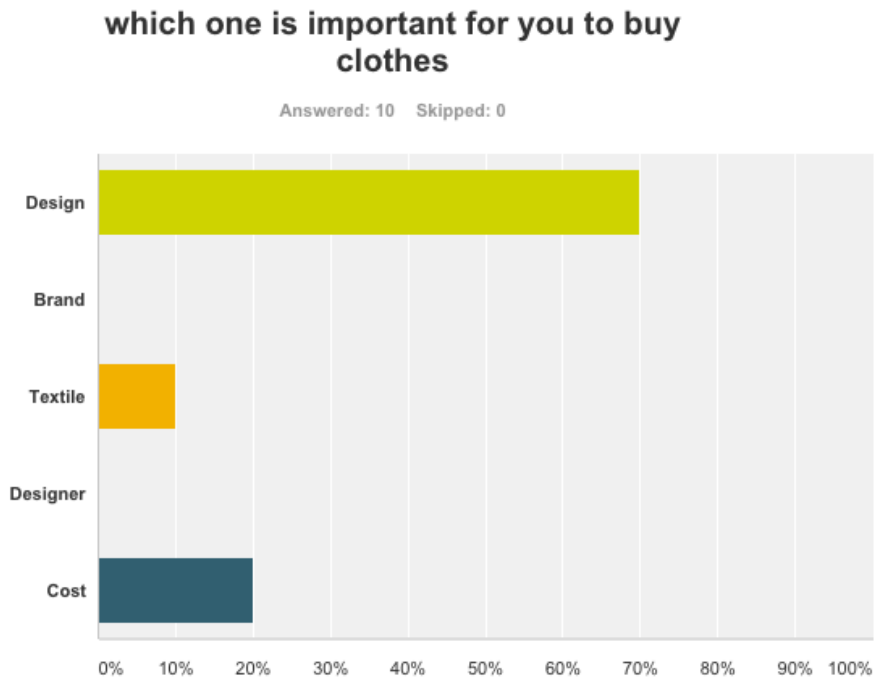

Figure 13: User Research Data Result

Differing from the male group, only 40% of respondents indicated that they knew about wearable fashion garments (Figure 14). Therefore, I followed up with each female respondent to find out the reason. After checking demographic information for each respondent, I found out that the key factor was age. Female respondents who were above age 50 were hesitant about embracing a wearable fashion garment. Based on this result, I decided to limit my user profile to a younger generation. Among purchasers with an interest in purchasing an interactive garment, females show greater interest than males when I exclude the respondents above age 50. This indicates that a female who is under

50 has greater potential to accept a wearable fashion garment, more so than for a male. From a company start-up point of view, attracting the most potential users is critical because it helps with brand positioning during the initial stage. Females show the same financial affordability as the male group when purchasing a fashion garment, the optimum price being lower than $150. No female respondents could afford a price higher than $700. (Figure 15)

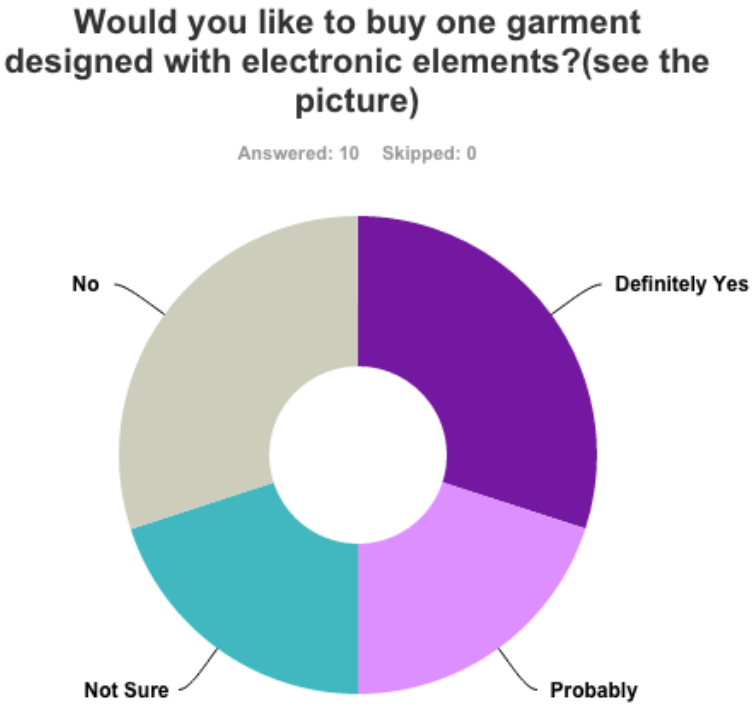

Figure 14: User Research Data Result

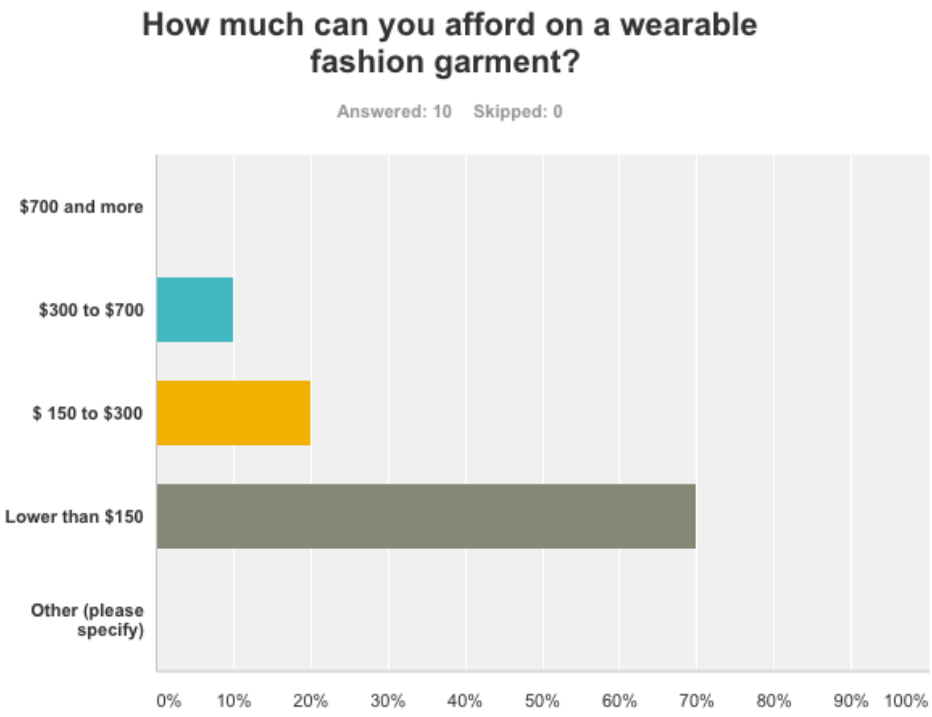

Figure 15: User Research Data Result

I inquired about concerns which both male and female respondents had about wearable fashion garments. Concerns included comfort, safety, too bold to wear, cost and battery. These were also factors influencing why wearables were not being adopted by the mass market. Clearly, some technology barriers currently exist in wearable devices and need to be addressed, but factors such as style, design, aesthetics and cost can be more easily controlled. These results provide an idea about how to design garments according to users' concerns. The garments need to be safe, comfortable, stylish, not too expensive and energy saving.

Conclusion:

Result 1: Design and Aesthetics are Keys to Success for A Wearable Technology Brand.

Design is the most critical point in wearable fashion design as shown by my research and that conducted by others. Current products in the mass market do not meet the aesthetic criteria required for consumers to embrace wearing them. According to the NPD Group's new wearable technology survey, 50% of consumers think the fashion appeal of wearables is an "extremely important" factor. Since wearables allow fashion to intersect with functionality, attracting the fashion consumer by appearance will be an important priority (Wright, 2015). Wearables will become mainstream only if they are purchased in the same way as clothing. To make wearable clothes or jewelry as appealing as regular clothing or jewelry on the mass market, aesthetics will be a key component to incorporate in the design of wearables (Reuters, 2013).

Result 2: Users identified as female, 18-30 years old.

User profiles can focus on a younger generation between the ages of 18 and 30 during the first stage because according to the questionnaire, females above 50 are reticent about embracing

wearable fashion garments. The consumer group therefore excludes people over age 50. On the other hand, females show greater interest in buying a wearable fashion garment, so the consumer group is targeted towards young females between 18 and 30. If it is possible, the brand can run two parallel series, which are a young ladies series for 18-30 year olds and a sophisticated ladies series for 30-40 year olds. But the prototype will focus on the 18-30 age group.

Result 3: Price point crucial to brand success

According to the questionnaire, the consumer group most interested in wearable fashion garments, young females, cannot afford to spend a large sum of money on the garments. 70% of the respondents chose lower than US$150 as their maximum affordable price. This data drives the basic design of the garment, so I need to control the production cost starting with the design stage. I can not design this garment by using materials that are too expensive. This data is very important for my continuing process, because it is an important decider in the selection criteria of the material that I will use and the garment design.

Result 4: Convenience and reliability are key concerns

Safety, comfort and battery life need to be considered in product design. Safety is a factor frequently mentioned by the respondents. It is a basic requirement for a wearable device. Beyond meeting basic need, convenience makes wearable technology feel like a natural, consistent part of our lives. The power supply, for example, can show how convenience factors into consideration. It is not convenient to take off a wearable device in the middle of the day and plug it in for charging. The power wireless technology would allow charging wearable devices over long distances instead of a stationary power source that maximizes convenience for users (Reuters, 2013).

Material Research

To design a functional garment, I needed to conduct research on fabrics and textile companies which can provide material for me. Starting with the questions, I went to the Messe Frankfurt Techtextil Exhibition. The exhibition was held from May 5 to 8 in 2015. It focused on the future vision of the textile industry. The exhibitors demonstrated the possibilities of applying technical textiles to diverse industries now and in the future. It had sections dealing with product technology, fibres and yarns, woven fabrics, nonwoven fabrics, coated textiles, composites, functional apparel textiles, associations and publishers,

and research, development, planning and consulting.

Since I had found my questions for determining the ideal interactive materials, I found some potentially useful companies at the exhibition. Some of them could also be material suppliers for DView. They are in different fields within the textile industry and may potentially prove to be design partners for DView future development.

For example the exhibitor Novanex can be a design partner for DView in design research and resource reorganization. Novanex is a design and product development agency specializing in innovative textile products. They assist their clients with marketing concepts and product ideas and provide access to their professional network. They have services such as knowledge transfer and consultancy, material screening and product development (concept, visualization, prototyping, transition into production). It is an agency for resource reorganization. It can be very helpful for my new product design and production.

There were some other potential suppliers in the exhibition such as Everest, Ecos and Polymax. Everest Textile Co., Ltd is based in Tai Wan. It provides theromochromic printing services. The service is named

Ever Thermochromic Print, which does special printing on PU film, PU leather or fabric to change colour reversibly with themochromic materials. It has two features with colour conversion with temperatures that can be applied to new fashion and lifestyle. Ecos Technology provides silver electrical conductors worldwide and silver nanowires represent the best electrical conductive material among the conductive nanomaterials. Recently, ECOS has opened a new strategic window which has led to more effective electronic applications and reduced raw material consumption. The cofounder of the company told me some theories of silver conductive material and explained the barriers and high costs involved in improving the silver conductive materials. They are very willing to cooperate with my future business. They could be an important supplier of conductive materials. The exhibitor Polymax provides coated and laminated fabrics and composites; waterproof/breathable polyurethane film for textile laminating by transfer coating; thermoplastic ploy urethane film for wide-range of application by blown-extrusion and flat-die extrusion. Waterproof is an important feature for circuit-based interactive garments. Future designs require soft waterproof materials to protect the circuit. Ploymax could become a future waterproof textile supplier.

Coming back from the exhibition, I researched other materials to determine the ideal material for the garment design to accommodate the results of the user research.

I recorded the features, price, dimensions, sustainability and stability and decided which one is ideal for the garment design. My primary supervisor advised me to focus more on threads and yarns. I think it can be a good angle for rethinking the final product. I compared materials to include luminous textiles, flexible OLED lights, a flexible OLED screen, an e-ink screen and thermochromic pigment. (Appendix C)

Luminous textile has an affordable price for everyday wear garment and it is comfortable, but there are already many design uses for these materials. The flexible OLED light and screens are too expensive and fragile. They are not suitable for my prototype. E-ink is not comfortable, so it also will not be used in this prototype. Thermochromic dyes and pigments change shade reversibly with a relatively small change in temperature. They can be used on textiles for creative fashion design or other fields such as camouflage design. They offer significant potential for aesthetic and functional textile design in the area of smart materials, which are designed to interact in a variety of ways with their environment (Chowdhury,2013). Unlike LED lights, illumining fabric and

other light based material, thermochromic pigment can be useful in more circumstances than a party or special event. It allows interaction in a daily common living scenario such as office and party. Thermochromic pigment has the lowest price among these materials. Temperature sensitive printing is a good choice for reducing cost. After comparing these materials, thermochromic ink proves to be the best choice, because thermochromic paint can create soft, comfortable and economic interaction effects on fabric.

Circuit Building Material Research

Conductive Material

As an important part of the wearable garments, a soft and comfortable circuit board is becoming a necessary and advanced feature. Material determines the structures of the circuit in the garment. I searched the materials that would enable this garment to be soft and washable or easy to dissemble. I compared the soft PCB print circuit, conductive ink, conductive glue, conductive tape, conductive yarn and soft copper wire.

Many companies provide online flexible circuit prototype services such as EPEC. They help consumers to design their customized circuits and to build the prototype. Designers can also print their own flexible

circuits by using copper paint and screen printing techniques or using other chemical compounds to form a circuit. Many designers design with flexible PCB on their wearable garment design. For example Stretchable Circuits designed Klight. The advantages of flexible a PCB board on a wearable garment are that the board is stable, easy to remove and easy to build into the garment. The disadvantage is that it is fragile. Plastic based flexible PBC board is also not as comfortable as our common garment textile, so it may not be an ideal material for daily wear.

Figure 16: Stretchable Circuit Klight. Reprinted from *The Klight project Award winning interactive dress.* n.d., Retrieve March 21, 2016 from http://www.stretchable-circuits.com/projects/fashion/klight

I compared three other materials in an experiment by creating a soft circuit with them. These three materials were copper tape, conductive paint and conductive glue. After applying them on fabric and testing with electricity, conductive glue worked very well because it could be integrated into the textile. The drawback of the conductive glue is that after the glue dries, it eventually becomes easy to break. However it can be an ideal circuit material for applying to a solid product. Copper tape had good conductivity during the experiment, but it can peel off very easily. Conductive paint is not very conductive when it is applied onto textiles. Considering the features of these three materials, I decided not to use them to build the garment.

I also compared the conductive and soft copper wire. Both worked very well. There are many types of conductive threads. Most of them are composited with stainless steel or silver. They are as soft as common garments and as conductive as wires. Conductive threads are the most common materials for wearable garments. Different types of conductive threads have different resistances. The longer the conductive thread, the more resistance it brings to the circuit. Designers need to consider the resistance of the conductive thread and the length they use for the circuit. Soft wire is not as comfortable as conductive thread, but it has

very low resistance. Designers do not have to consider the length of the wire. Therefore, I decided to use soft wire and conductive thread together in my circuit design.

Name	Manufacturer	Source	Part number	Ply number	Resistance (Ω/ft)	Material	Notes
Stainless thin conductive thread	n/a	Adafruit	640	2	16	316L stainless steel	Stiff
Stainless medium conductive thread	n/a	Adafruit	641	3	10	316L stainless steel	Stiff
Stainless thin conductive yarn / thick conductive thread	n/a	Adafruit	603	3	12	316L stainless steel	Furry
Conductive thread (thin)	Bekaert	SparkFun	DEV-10118	2	9	Stainless steel	
Conductive thread (thick)	Bekaert	SparkFun	DEV-10120	4	4	Stainless steel	
Conductive thread (extra thick)	Bekaert	SparkFun	DEV-10119	6	1.4	Stainless steel	
Conductive thread (117/17 two-ply)	Shieldex	SparkFun	DEV-08544	2	300	Silver-plated nylon	Likely to oxidize over time, discontinued
Conductive thread (234/34 four-ply)	Shieldex	SparkFun	DEV-08549	4	14	Silver-plated nylon	Likely to oxidize over time, discontinued
Conductive thread (60g)	n/a	SparkFun	DEV-11791		28	Spun stainless steel	Hairy

Table 4: Comparing Conductive Thread. Reprinted from *Make: Wearable Electronics*(p. 41), by K. Hartman, 2014, Canada

Heating Material

I acquired some heating yarn samples from BEKAERT. It has an excellent heating effect. Some types of these samples are coated and they are waterproof to some extent. The sample amount was not enough to build my prototype. I have to leave it for future designs.

Another restrict of heating yarn is that it is limited when creating interactive patterns because of it increases resistance when in long distance that prevent it to reach the temperature. It increases the design difficulties, therefore I used the regular conductive thread that I bought from Creatron Inc. in the initial prototype testing.

Figure 17: Heating Yarn from BEKAERT.IT

I aquried another heating material which I obtained from a company called Litex Textile, located in Tai Wan. They provide 5v-12v batteries for powering non carbon fiber waterproof medical electric heating for clothes. After I tested the parameters of this fabric, I found it works very well within 10 inches with a 9v battery.

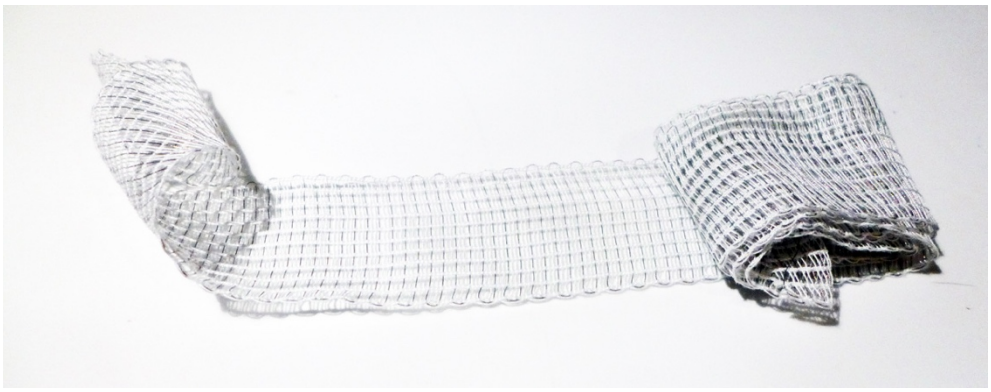

Figure 18: Heating Textile from LITEX TEXTILE

It has different widths that can create different interactive patterns. I decided to use this material for my final prototype.

Communication technology comparison

There are two choices to connect the mobile and the garment: Bluetooth or WIFI. Bluetooth is stable for creating one to one communication. It has free data transfer and it is easy to switch on and off. But Bluetooth has to rely on a mobile phone, and it only supports one to one connection. When mobile communicates with cloud data, the application uses Internet data. Bluetooth does not support multiple device connection. WIFI can transfer data directly from a cloud server and it does not rely on a mobile device. It is totally free for data transfer, but it relies on location. If the space does not have WIFI, not all of the functions will work.

After comparing these two methods of data communication, I decided to use Bluetooth for data communication to ensure that the user can use the functions anywhere with their mobile and that they can switch the functions on and off. Therefore, I sought out a microchip board with Bluetooth capacity with arduino core. I found the Blend micro board met this need. Blend micro is the first integrated development board. It "blend"ed Arduino with Bluetooth 4.0 Low Energy (aka BLE or Bluetooth Smart) into a single board. It is targeted toward makers who develop low power Internet-Of-Things (IoT) and it projects quickly and easily.

The micro-controller unit (MCU) is Atmel ATmega32U4 and the BLE chip is Nordic nRF8001. Blend Micro runs as BLE peripheral role only and it allows BLE central role devices to establish a connection with it.

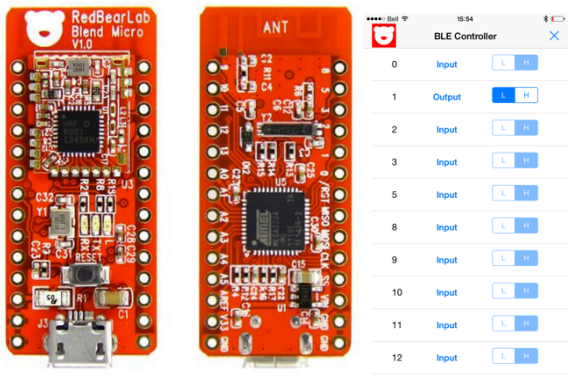

Figure 19: BLEND Micro board and Its Operating ios Application. Reprinted from *RedBear Duo*, n.d., Retrieve March 21, 2016 from http://redbearlab.com/blendmicro/

Design Decision on Rational Research

I conducted research on user needs and materials in order to determine how to allow interactive a functioning garment to gain mass market acceptance. The garment must address concerns of its targeted consumers. These concerns include lightweight, comfort, safety and cost. Currently electronic decorated garments are not confronting these barriers in the marketplace. According to the research results, I concluded that if a garment is lightweight, comfortable, safe, low cost, and attractive enough, entertaining and fashionable, the garment will be successful in the mass market.

To ensure success, we used the research data to design a product for target users, and we chose the most suitable material determined by the data. The whole design process was driven by the research results with the goal of making the product a commercial success. I speculated that placing thermochromic printing on garments to create dynamic patterns for user interaction via a mobile device would be accepted by the mass market by young girls, young female professionals and consumers of progressive fashion.

Why does this product use thermochromic pigment? According to research by Gretchen Anderson and Gwanhoo Lee in their *Why consumers (don't) adopt smart wearable electronics,*

> *"the second main factor is price. Consumers will buy the iPod jacket, like any product, only if it fits within their acceptable price range. Because consumers generally demand lower prices, we need mass production to lower the cost and, in turn, the retail price. (Anderson, 2008)"*

This result is also verified by this thesis research in the user needs research chapter. People who are very open to wearable technologies tend to be in a young generation. This means that most of the consumers who can potentially buy wearable products cannot afford to pay a high price for the technological integration. Thermochromic pigment is a cheaper component that can create lightweight interactive patterns on fabric, so it could be an ideal material for fashion in mass market.

Design Evolutions

After making the decision, I began experimenting with thermochromic paint. The goal of the experiment was to determine the best medium

to use for screen-printing.

Figure 20: The Testing of Thermochromic Pigment Powder Create Thermochromic Paint

I chose thermochromic pigment that I bought from amazon.ca.

Colour-shifting thermochromic colourants are available with many activation temperatures, ranging between 15 °C and 65 °C. However most colourants are produced in three standard temperature ranges, namely cold (approx. 10 °C), body-heat activated (approx. 31 °C) and warm (approx. 43 °C)[9]. I bought four colours: red, blue, yellow and black, which change colour at 31°C. These colours are used for screen printing as CMYK colours. I chose a blue colour pigment to test on the fabric. Then I mixed the speedball screen printing base medium with the pigment, using a 3:1 ratio. After the paint dried, it changed colour from pure blue to light blue. The drawback of this method is that the paint dries very slowly, requiring almost five days to completely dry. I use this paint temporally, but I will use a better medium for future development.

To speed up the drying process, I added Golden GAC-900 fabric painting medium. The proportion of the two mediums was 1:1. The testing result was not very good. The colour appeared to be diluted and the colour changing time was slow. In addition, the Golden GAC-900 label revealed that it contained formaldehyde, a chemical identified by the State of California as carcinogenic. Therefore, I decided to stop using this medium.

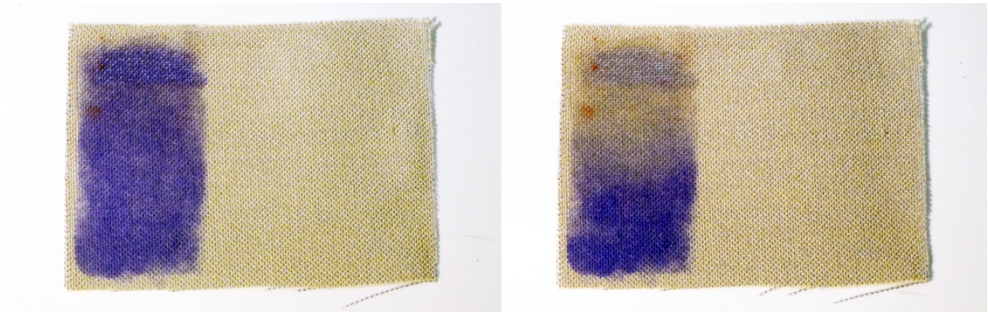

Figure 21: Thermochromic Paint Testing on Fabric

To create a dynamic pattern, I needed to select the ideal heating media for working with thermochromic pigment on fabric. I began by using conductive thread to test the feasibilities, because conductive thread is less costly and is easier to work with when building a circuit. I placed a short section of conductive thread under the 9V voltage circuit. The result proved my hypothesis that conductive thread can change the pattern of a thermochromic print according to the shape of the conductive thread that sewing on the fabric.

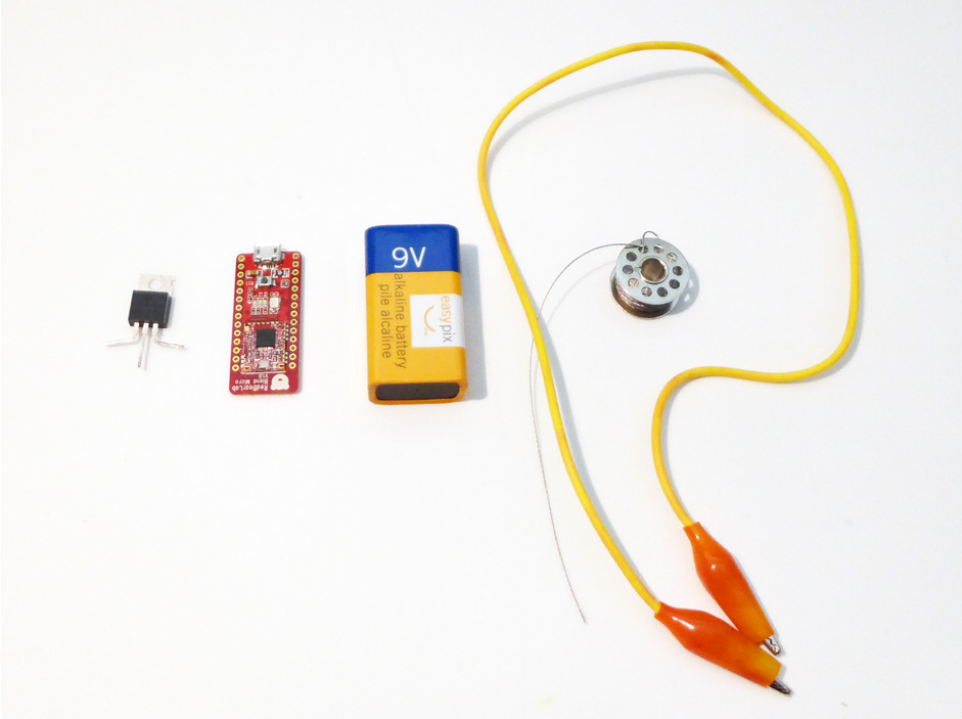

Figure 22: Circuit Building Components

The next step involved building the remote-controlled circuit using a Blend micro board. The circuit uses the DC motor circuit. This circuit enables usage of a 5-voltage micro board using up to a 9-voltage battery that provides power to heat up the conductive thread. The heating command is sent by the Blend mobile application when the user switches on the power button.

This circuit works very well. The mobile phone (iPhone 6) can be used as a controlling device whether or not the thermochromic paint on the fabric changes colour. By switching the high and low button for each pin on the micro board, the circuit receives electricity through the

conductive thread which heats up the thermochromic pigment. After the thermochromic pigment reaches 31 degrees, its colour starts to fade.

Prototype

Prototype One

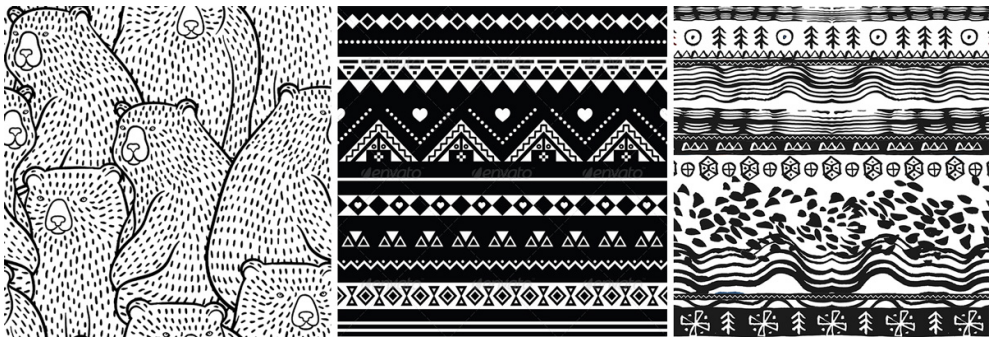

Figure 23: Pattern in Three Prototypes

Pattern design is a critical factor in this prototype because it must be aesthetically pleasing while incorporating a circuit. Instead of using a randomly chosen pattern, I needed to consider how different colours may interact with each other and how the user may interact with the pattern. I also needed to think about what pattern showed the best interaction effects on it while rendering the interaction interesting enough to attract consumers to buy it. On the other hand, the pattern design also needed to consider the arranging of the circuit. To combine all of the requirements together, the first version of the pattern focused on colour combinations. The pattern consisted of

cycles of a group of six bears. Each bear in its group has one primary colour and one shifting colour, so six bears produce 36 different pattern combinations. The bears' "fur" is comprised of dots that can be sewn by hand using conductive thread along each strand of hair. For technological considerations, the bears having the same colour are found in the same line, as it is easy to create a circuit along the line while not disturbing the others.

Figure 24: Colour Combinations of Bear Pattern

I printed out the patterns and joined them together on paper first to measure the pattern size. Then I printed the patterns on transparent film and joined them together. I blended the sensitizer and photo emulsion. After the emulsion became green, I evenly brushed the

emulsion onto the screen and put the screen in a dark room until it dried.

I exposed the screen for 15 minutes under the sun (a little bit cloudy that day). After I subsequently washed out the screen, the unexposed part washed away and a pattern remained on the screen. Then I used the squeezer to squeeze the paint through the screen to create a print on the fabric.

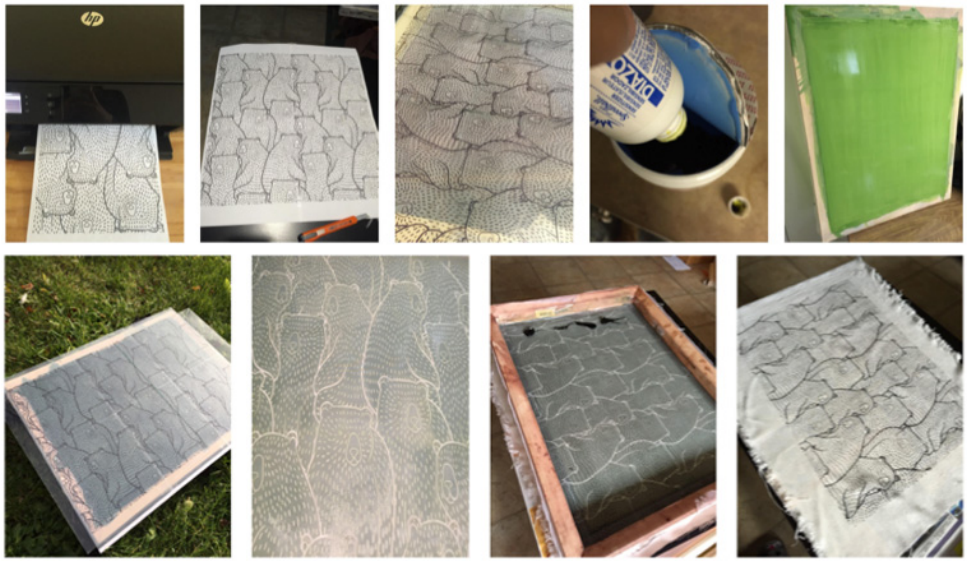

Figure 25: Screen Printing the Bear Frame on Fabric

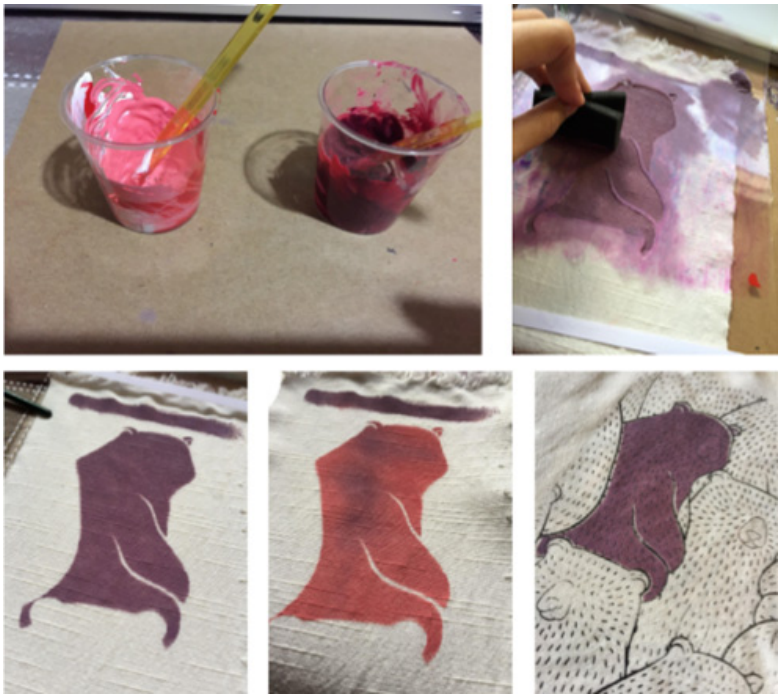

Figure 26: Synthesis Paint Testing and Print on Fabric

I then combined the colours with thermochromic pigment and regular pigment in order to create the effect of changing colours. I uses the theory of two primary colours creates a secondary colour on the colour spectrum. Then I used regular pigment for one primary colour and thermochromic pigment for another primary colour to create a secondary colour. When thermochromic pigment fades, the colour changes to the primary colour of the regular pigment.

In order to create the effect that I predicted, I tried different concentrations of two different types of pigment. First I choose a 1:1 blend, but the thermochromic pigment proved to be too thin. Then I

tried 1:2, 1:3 and 1:5 proportions without a satisfactory result. Finally, a ratio of 1:4 regular pigment with thermochromic pigment worked very well.

Then I sewed the print of the bear with the synthesis paints on previously printed bear fabric, and sewed the conductive thread along the bears' hair points. I heated up the thread with electricity, but the result did not match my expectations.

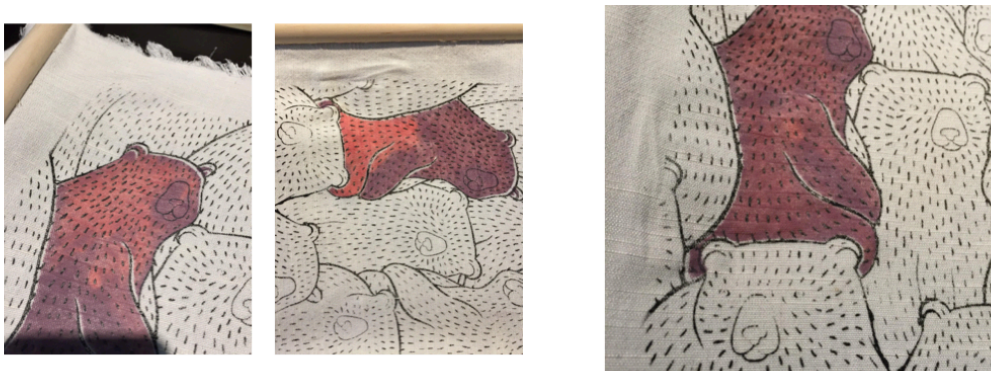

Figure 27: The First Prototype Testing Result

The first prototype failed because the bear required conductive thread which was too long, resulting in the resistance being too high to heat up the conductive thread. Only half of the bear was able to produce the expected effect.

Prototype Two

Learning from this failure, I decided to conduct more physical testing

before moving onto the second prototype.

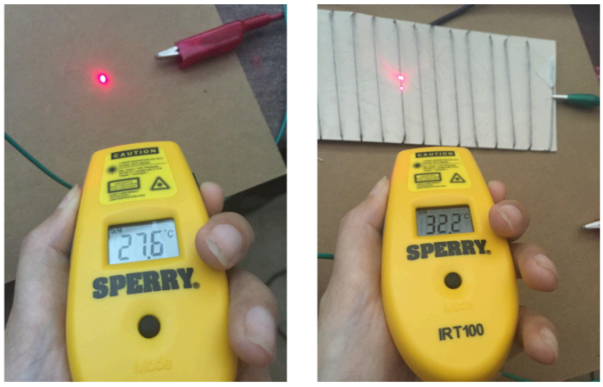

Figure 28: Temperature Testing on Sufficient Length of Conductive Thread

To ensure that the prototype worked in accordance with my expectations, I tested the temperature with conductive thread of sufficient length. I found that the conductive thread only worked when it was under 45cm long in a 9V circuit. Then I switched to a pattern with strait bold line and traditional symbols in two colours that simplified the functions. The second pattern was also more sophisticated and thus more suitable for garment design. The conductive threads were sewn under the fabric in the second prototype, making the surface look flat as in common fabrics. After I tested each line with electricity directly, I sewed the Blend micro board into the fabric and connected the micro board with conductive thread according to the designed circuit. The result matched the original expectations. Users could use their mobile device to control the

colours and patterns on the fabric. Different pattern combinations could be created by users' commands.

Figure 29: Second Prototype and Its Components

Final Prototype

After the success of the second prototype, I started to make the final prototype, namely the mobile-controlled dynamic pattern garment. Differing from the second prototype, I used heating fabric instead of conductive thread. I used the screen printing technique to print the pattern, which was chosen based on the fashion trends of 2016.

Why is design critical in wearable fashion product design? At the moment we don't have enough information as to whether such fabrics are actually feasible, if they will ever be affordable, and if people will actually wear them. The main challenge is to find a way to reconcile

technology with aesthetics to transform products we need into garments we want (Arlidge, 2014)." Luxury is built on innovation, integrity, intelligence, usefulness, design and elegance," says Floriane de Saint Pierre . According to the study by Gretchen Anderson and Gwanhoo Lee in their *Why consumers (don't) adopt smart wearable electronics,* there are four key factors that affect shopping decisions of consumers (Anderson, 2008). The first and most important factor for a wearable product is design. The user research section in chapter four of this thesis also proves this factor. Therefore, to successfully launch the design into the marketplace, a fashion trends study is necessary, especially for a new fashion brand. Differing from general fashion design, the design for this dynamic pattern garment needs to consider the circuit under the fabric. Therefore the stripes natural and technology symbols were chosen for this fabric as its main theme.

According to the Trendstop forecast for Spring/Summer 2016, striking and bold were expected to be in. For the purpose of creating this second prototype quickly I used a royalty-free pattern from Patternbank.com. I selected one that included archetypal shapes and motifs that can be found in traditional as well as contemporary and technological cultures across the world.

Figure 30: Trendstop forecast that contemporary stripe becomes the trend in 2016. Reprint form Women's Exotic Prints S/S 2016, n.d., Retrieve March 22, 16, from https://www.weconnectfashion.com/articles/women-s-exotic-prints-s-s-2016

Classic denim blue was also expected to become a core colour for the summer of 2016. This blue can add sophistication using its dark and inky styles. The shaded colour applied to a manipulated stretch jersey and relaxed utility wear was predicted to be a trend in the summer.

Figure 31: Thakoon, Carven, Lacoste, all Spring/Summer 2016. Reprint form *Key Color Trends Hot off Sprint/Summer 2016,* n.d., Retrieve March 22, 16, from http://blog.trendstop.com/2015/10/key-color-trends/

Snorkel blue is also one of the colour trends in 2016, as forecast by pantone.com.(Figure 32) A maritime-inspired snorkel blue falls within the navy family, but with a happier, more energetic appearance.

Figure 32: Designers Using Snorkel Blue in Their Design. Reprint from *Spring 2016:A Transporting and Transformative Canvas.*, n.d., Retrieve March 22, 16, from http://www.pantone.com/pages/fcr/?season=spring&year=2016&pid=11#snorkel-blue

Using the trend forecast, the final design utilizes a contemporary stripe pattern in a snorkel blue colour. Considering that targeted consumers are females ranging from 18 to 30 years of age at the start stage of DView, I selected a lighter and brighter feeling pattern for this garment.

Figure 33: The Pattern Selected for the Final Product. Retrieve from http://www.patternbank.com

To convey the dynamic pattern concept, I designed a simple top with a printed pattern piece sewn into its front. The design is very simple for the user to understand and easy for building the circuit. I screen printed the selected pattern onto a silky fabric, namely a synthesis of red thermochromic pigment with regular black pigment. After heating up the fabric, the red parts on the fabric became gray.

Figure 34: Screen Printing the Final Pattern for Final Prototype

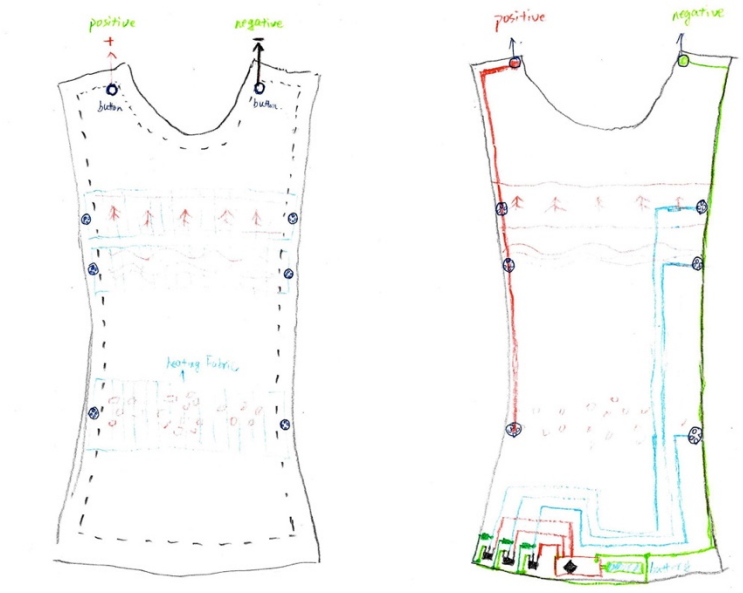

Figure 35: Circuit Design According to the Cutting Piece of the Garment

Before I started building the circuit for this garment, I read Kate Harman's "*Make: Wearable Electronics*" (Hartman 2014, p.79). She

states that the placement of electronic components on garments greatly influences the comfort of the wearable product. Body movements must be considered before the circuit design. It is better to put the behaviour items close to core components and run connections along seams and edges. So, for my prototype I took full advantage of the seaming on the garment. The trunk circuit is sewn into the seams and the core components placed at the bottom of the garment so as to not affect users' daily movements. The final prototype still uses a Blend micro board as its processor as per the second prototype. The working theory is also the same as for the second prototype. The differences are that it updates the circuit shape according to the garment design and it uses heating fabrics instead of heatable conductive thread.

Figure 36: The Appeal of Final Prototype

User Testing

User Testing One

I brought prototype two to the Future Era exhibition to get feedback from users, and to see if their comments would lend support to my hypothesis that the interactions between a mobile device and fabric could attract targeted user groups. The key concerns that collected from questionnaire such as comfort, safety and battery. were addressed and fixed in this prototype.

Figure 37: Prototype 2 Exhibited at Futuera Fashion Show

After I communicate with the visitors pass by my booth, I get the feedback of this prototype. The feedback from visitors was very positive. 80% visitors showed great interest in and passion toward this prototype. Almost every visitor who talked with me gave positive feedbacks, which really surpassed my expectations. In addition to the positive reception, I also received questions from visitors. The most frequently asked question was, "How can I use this fabric?" The second question asked most often was, "Is this fabric light/comfortable?" The third most popular question was, "How does this functionally work?" Some other questions included: "Is this fabric okay for my health?" "How much power does it have?" "If the power is

too high, will it be harmful to my body? If so, should I avoid putting it in front of heat?" These questions reinforced my hypothesis that I formulated from the user research, specifically that all of the users' concerns would pertain to comfort and safety of the fabric. After the visitors learned about the features of this prototype, they became very excited about the idea. When I asked some visitors if they would be willing to purchase and wear a garment made by this kind of fabric, they gave very positive responses.

User Testing Two

After I completed the final prototype, I picked three users for testing the prototype garment. They were females aged 23, 26 and 27. One was a student and the other two were young professionals. I asked them questions pertaining to the comfort of the garment, their adoption of it and any confusion regarding technical interaction they needed to have addressed. All of them expressed interest in the garment and said they would like to wear such type of clothing in daily life. However, one respondent stated her preference would be to wear it at special events or parties. All of them were very satisfied with the comfort of the garment and felt it did not differ from the comfort level of other common garments. They were confused about the user

interface which used a mobile application, so I needed to teach them how to use a mobile device to interact with the garment. However, once they understood how to control the functions, they found the interaction very entertaining. They also asked me about safety and washing the garment. This proved again that safety and washing the garment were key concerns of consumers when asked about wearable garments. I also received some unsolicited comments regarding this garment such as cost and future functions. Participants expressed concern about price, stating that if it was expensive, they would prefer to buy one only for a special event or a party. One respondent suggested integrating the functions with health and wellness goals, such as using electricity to relieve painful muscles. I found this idea very interesting, and emerging fashion with health could be a new topic for research and development. In summary, the respondents were satisfied with the garment and found it and its interactions acceptable for daily wear. They also provided good suggestions for future research and development such as refining the application design and functions.

Conclusion and Future Works

The feedbacks of user testing indicate that users are satisfied with the

final design. The users have high desires to purchase this garment. At the same time, the product addresses most of the concerns of the target consumer that make them want to buy. This design approach helps define the user group. It in-depth studied the user behaviors and psychology to improve the product. The advantage of this design approach is that it can understand the needs of users to design products to meet customer demand for the production of mass consumer goods. From the positive feedbacks of the users, the user-centered design methodology applying to fashion design can effectively design wearable fashion products for designed consumer groups. If I keep refining the product and put it into market to test it with real consumers, the garment will be finally be suitable for mass market. It will have a predictable promising future.

According to current design and user research results, there are still some areas that need upgrading in the future.

- Better utilizing the structure of the garment design, such as belt and buckles. Building the electronic components into the belt increases convenience and the belt material covering the belt can create a waterproof environment. Accessories and buckles could be perfect battery containers.

- Improve the battery and circuit design. Currently we use a 9v circuit. The performance time is only 6-8 hours. If I use a 5v circuit, battery endurance will extend to 10-12 hours, i.e. a day's wear. If a high capacity battery is used on the garment, performance may extend to 16-18 hours. This amount of time could be sufficient for 3-4 days of interaction.

- Improve the aesthetics and design collections. The prototype is only a top and the pattern is too simple. For future works, pattern design and fashion design need to be enhanced (Figure 4-31). I propose to work in collaboration with experienced textile print designers and fashion designers. I believe this will allow me to future explore and develop the visual and tactile qualities as well as bringing me into more direct contact with consumers.

Figure 38: Future Design References. Pattern Retrieve from http://www.patternbank.com

- Enrich the design collection. To set up a fashion brand, a design set is required for each season.(Figure 4-32)

Figure 39: Future Design Sets Example. Reprinted from "Fashion Forecas Winter 2015/2016", n.d., *CBI Ministry of Foreign Affairs.*

- Integrate social network and big data into the interactions.
- Combine the aesthetics functions with e-health functions.
- Use organic thermochromic pigments.
- Design the interface for mobile applications and clear the functions on the application according to the interactions.

BUSINESS STRUCTURE

Company Core Values

Our values direct us to continuously create better ideas for a better future.

Collaboration: The best way to get inspirations. Respect everyone around you.

Passion: Use your energy to change the world.

Diversity: Express your identity with our product.

Quality: There is never an ultimate best product. We always strive to develop an even better one.

Company Size

The company is planed to start with three core cofounders. It will expand to have up to 10 people in its headquarters according to its online sale business. After local stores open gradually, the number of employees will increase. It is expected to reach 10 local stores at the

end of 5 years, and the employee number is expected to reach 50 by then.

Departments

The company starts from a basic department to launch the product, and it will enrich this department after it achieves sales success and opens local stores.

Basic Department

- Fashion Design
- Technology and Research
- Purchase
- Marketing

Future Added Department

- Online Store Management
- Sales
- Customer Service
- Finance
- Human Resources

At the first stage the company will operate with limited funds, so some departments may be merged into one and headed by one person.

Product Series Developing

The products is planed to be sold online initially and in stores later in North America and China. Since the company will start with online sales, it will not require a full product series as couture. The first series contains basic wears, which include tops, dresses, skirts, jackets and pants. We also sell thermochromic accessories without mobile interactive functions to help consumers accept the technology. After 3-5 seasons, our series will contain 30-50 suits in each season.

Differing from the traditional fashion sector, our product has a Mobile Series, an Environment Series and a Social Series. The Mobile Series has basic functions for users to use their mobile device for controlling the pattern on the garment. The Environment Series allows its users to interact with environmental data. The pattern will be changed by environmental data, and the design will mix with more environmental elements. The Social Series allows users' friends and families to change the users' pattern on the garment. It incorporates a diversity of motion as well as communication and it gives more utility to garments. We also create designed patterns for groups or organizations to help them achieve their special goals, such as promotional products or charity events.

DView have free repair services and recycle policies. Our consumer can use old clothes to redeem for credit toward purchasing a new garment. We also build a community that regularly holds events and parties for our consumers, thereby increasing consumer loyalty. At the same time, the community helps to promote the concept of interactive garments. It aims to increase the targeted market's openness to adopt this new type of garment.

SALES AND MARKETING

Sales Proposition

The main (90%) revenue comes from the end-users who buy the design and product. As the technology matures, we will cooperate with other fashion brands and provide technological support to other expanding businesses, and the revenue model will change to a "technology patent" fee.

Marketing and Sales Strategy

Using "good value for money" as a key strategy in developing the "middle price" wearable market, the target consumers will be college students and entrance level young female professionals who are keen on new technology. Our marketing strategy is to take advantage of a full range of all types of media to target our consumers. We brand our

products as a way in which people can develop innovative ideas, create fashion styles and gain wearable products information, as well as being a means in which they can express their individual identities. Differing from the traditional garment industry, we market our products not only on main fashion sales channels, but also on technology information channels. Another difference from traditional fashion brands is that our online sales and direct sales will offer after-sales service. Consumers can get unbeatable service when they encounter problems with their products and repair service will be easy to reach. A store will open in Canada first, and then expand to the US. Five stores are expected to open in North America. The stores will open in China in the company's third year. Eight stores are expected to open globally in the third year of operations. If local stores prove profitable, we will keep opening local stores in the next two years to reach 20 stores globally. Another feature of our sales strategy is to set up a community for our consumers to share their experiences and ideas. They can wear their interactive garments to attend community events. The community can help our company to increase the size of the user groups in a very grass roots manner. At the same time, the community can warm potential consumers to the idea of adopting interactive garments. It is also a very direct way to obtain feedback

from consumers.

The specified promotion execution is separated into two sections, which are online and offline.

Online marketing:

- Official web site.

  After creating the website, the company can use search engine optimization techniques to give the website a prominent rank and high visibility.

- Blogger
- Free try online campaign
- Online banner advertising delivery
- Social network

  Social media is also a very powerful marketing tool which I can use for increasing the volume of traffic to the official website.

- Video
- Email

  The company can regularly send newsletters and a catalogue containing pictures and descriptions of my products, with pricing, to people on the mailing list.

Offline marketing:

- Fashion magazine
- Fashion show
- Event hosting

  The company can organize seminars and conferences that teach people the trends of new fashion that incorporates technology.

For the first year the promotional budget is US$75,000, which is get from Venture Capital investment. The second year's promotional budget is US$150,000 and the third year is US$420,000.

Objectives

Our sales objective is to maximize brand awareness with potential consumers and convert technology fans into buyers. During the first half-year we will finish our initial series design and produce it for sale. The sales objective for the first year is to reach US$558,000 and to have the product known in the marketplace. It aims to achieve a modest operating profit within one year and establish a professional design and technology invention team. The second year sales objective is US$5,157,000 and the third year is expected to be US$8,982,000. Online sales will change from 100% of the total sales

value to 30% of the total sales value as stores open. Revenue is expected to increase from North America and China equally after our company opens its stores in China.

Target Sectors

University students

High school students

Young female professionals

Fashion forward consumers

Event holders

Stage performance holders

Companies that want to expand their business

Textile research institutes who want to cooperate with our technologies

Pricing

All dollars in the business plan are in US dollars

The cost of raw material and the manufacturing of each suit:

Thermochromic printing: The printing cost is US$2/meter; therefore, it is approximate US$4 for each suit.

Fabric: US$5-US$30 per suit: The price is according to the fabric used for the garment.

Chip board: US$15-US$25 per suit: The price for chipboard fluctuates by the purchase amount. The more we purchase, the lower price we can get.

Sewing cost: average US$15 for common sewing and soft circuit sewing of each suit.

Conductive yarn: average US$2

The total cost of raw material and manufacturing ranges from US$41 to US$76

After factoring the design cost, promotion cost and invention cost into the product price, the final price for our products ranges from US$150 to US$480.

FINANCIAL OVERVIEW

Three Year Model

The business starts with US$50,000 with Venture Capital investment. It starts with US$15,000 cash for its basic requirements and salaries. The milestone for the company is the 7^{th} month when the first product launches, and it is expected to stop loss within the first 13 months. The company expects to recover the costs in the first three months of the second year. The growth rate of sales in year 2 is 45%, and the growth rate of sales in year 3 is 60%. The net profit is expected to

reach US$ 72,157.43 in the third year.

FINANCIAL PLAN

Dview Fashion Inc

PROFIT AND LOSS ASSUMPTION			
	Year 1	Year 2	Year 3
Annual cumulative price (revenue) increase	0.00%	45.00%	60.00%
Annual cumulative inflation (expense) increase	0.00%	40.00%	55.00%

INCOME			
	Year 1	Year 2	Year 3
Revenue			
Garment and accessories	104,000.00	150,800.00	241,280.00
Total revenue	104,000.00	150,800.00	241,280.00
Cost of Sales			
Garment and accessories	16,640.00	23,296.00	36,108.80
Cost of goods sold	16,640.00	23,296.00	36,108.80
Gross Profit	87,360.00	127,504.00	205,171.20
Other income (specify)	-	-	-
Toatal Non-Operation Income	-	-	-
TOTAL INCOME	87,360.00	127,504.00	205,171.20

Table 5: Three-Year Financial Over View (Page 1 of 2)

EXPENSES			
	Year 1	Year 2	Year 3
Operating expenses			
Sales and marketing	2,000.00	4,000.00	6,000.00
Human Resources	40,000.00	60,000.00	80,000.00
Utilities	500.00	700.00	1,085.00
Research Equipment	500.00	1,000.00	1,500.00
Interest expense on long-term debt	1,352.70	1,070.17	779.16
Real estate expense	6,000.00	7,500.00	11,625.00
Total operating expenses	50,352.70	74,270.17	100,989.16
Unexpected Expenses	700.00	1,000.00	1,100.00
Other expenses	-	-	-
Total Non-Recurring Expenses	700.00	1,000.00	1,100.00
TOTAL EXPENSES	51,052.70	75,270.17	102,089.16
TAXES			
Income Tax	10,892.19	15,670.15	30,924.61
Other Tax (specify)	-	-	-
TOTAL TAXES	10,892.19	15,670.15	30,924.61
NET PROFIT	25,415.11	36,563.68	72,157.43

Table 5: Three-Year Financial Over View (Page 2 of 2)

Five Year Model

The company also has a long-term plan. After 3 years of development, the revenue is expected to be stable. The net profit will keep increase 30% each year, and the local store will keep open accordingly. The company will keep working on other inventions for the fashion field. It will maintain contact with other material production companies to create inventions. At the same time, our company will cooperate with

other firms to expand their new business. On the other hand, the company will keep its tradition of conducting research to learn about user experiences with the designs. The goal for the next five years is to become the leader in the field of new technology melded with fashion.

Business Structure and Ownership

The company will be registered as a partnership company in Ontario. This kind of company is flexible and easy to grow. It is very suitable for a start-up company. It will be held by three core members: a computer engineer, a fashion designer and a marketing specialist. The advantage of this group is that each member can play a key role in launching the product and successfully run the company. The responsibility is shared equally among all members. All the debt and revenue will also be shared equally among all members. The disadvantages of registering as a partnership company include unlimited risk, possible development of conflict between partners, and each member bearing financial responsibility for business decisions made by other partners.

This type of business structure will change to a corporation once it seeks out investment. We will sell our shares according to the investment amount. As the value of the business grows, we will sell

more shares to investors. Once we have reached the company listing standards, we will sell the company's stock to investors.

CORPORATE SOCIAL RESPONSIBILITIES

Corporate social responsibility (CSR) refers to a business practice that involves participating in initiatives that benefit society. Business News Daily cited Alexis Magnan Gallaway's (Owner of fashion company Pax Cult) indicates " Technology has brought global connectivity and enabled advocacy and awareness for social situations that were once obscure" (Taylor,2015) We are facing a global problem of carbon dioxide emissions in the industrial sector. DView garments specific focus on reducing carbon dioxide emissions. The DView garment allows people to use different colours to match different circumstances and different bags, shoes and accessories and it will reduce the number of garments in our wardrobe. At the same time, it will reduce the cost of garments by decreasing the garment amount required for matching different parts of an outfit. For the material part, organic thermochromic paint is available on pattern printing. The garment creates an environmental friendly and healthy material for consumers. This innovative fashion brand will contribute all its abilities for a sustainable developing in the future.

SUMMARY

The wearable fashion industry has received limited acceptance by the mainstream fashion industry. More research is needed to better understand the market and users. The fashion brand DView will specialize in promoting wearable fashion through interactions in daily expressions by aligning the design method used in the fashion design process with wearable fashion design that embraces the digital age. Accompanying the growth of the wearable industry, the convergence of wearable technology and fashion is a compelling force behind the rise of wearable fashion companies. DView will become a pioneer which leads the way for giving wearables mass market acceptance. At the same time, there will be more competitors in this field. DView will keep its core value of continuously creating better ideas for a better future and will maintain its passion for creating innovative wearable fashion products for consumers.

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Appendix A Messe Frankfurt Techtextile

Name	Website
Novanex	http://www.nova-nex.com
Description	**How to use it**
Novanex is a design and product development agency which specializes in innovative textile products. They assist their clients with marketing concepts, product ideas and provide access to their professional network.	It has following services Knowledge transfer and consultancy Material screening Product development (concept, visualization, prototyping, transition into production) Product management (coordination of optimizing products, communication with suppliers) Project management (coordination of the partners and suppliers) Guidance in marketing (trade fair concepts, stand-up displays, give-aways) They provide valuable consulting services, but its price is higher than my affordance, but it is a potential business partener

Name	Website
Everest Textile Co.,Ltd	http://www.everest.com.tw/index_us.aspx
Description	**How to use it**
Everest Textile is an R&D oriented and vertically integrated textile manufacturer that specializes in yarn spinning, twisting, weaving, dyeing, finishing, printing, coating, laminating and special finishing. Everest develops and supplies high value-added and innovative products to global leading brands in sports, outdoor, city, casual and industrial materials etc.	（1） Ever Thermochromic Print can print Special printing on PU film, PU leather or fabric to change color reversibly with themochromic materials. It has two features with color conversion with temperature that can apply on new fashion and lifestyle.  （2） It also provide warter-proof and wind-proof materials. These material can also help to build my project to protect the electronics from water.

Name	Website
Venture Join International/The Ecos Technology **/ agpure/ ras materials**	http://rasmaterials.com/research-development.html http://rasmaterials.com/ecos-products/technology.html
Description	**How to use it**
Ecos technology provides silver electrical conductor in the world and silver nanowires represent the best electrical conductive material among the conductive nanomaterials. Now, the ECOS opens a new strategic window, which leads to more effective electronic applications and reduced raw material consumption.	After I talked with the co-founder of this company, they are very like to provide experiment materials for me. As the conductive material, there are many possibilities. This company is going to be an important material supplier.

Name	Website
AUDACES	http://www.audaces.com/us http://www.audaces.com/us/development/audaces-3d
Description	**How to use it**
It produces software for fashion technology towards students and teachers, teaching organizations and clothing manufactures. The software includes the whole line of clothing production from creative idea to production and development.	It produces software for fashion technology towards students and teachers, teaching organizations. If I can set up an industry of high-tech fashion, my company might use the software to control its creative and producing line.

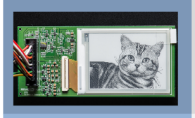
Name	Website
EVONIK INDUSTRIES **P84 Fibre Characteristics**	http://corporate.evonik.com/en/Pages/default.aspx http://www.p84.com/product/p84/en/products/polyimide-powder/pages/default.aspx
Description	**How to use it**
The P84 fibre is a polyimide-based fibre with a typical textile character. Polyimides are known to e used in a wide range of operating temperatures starting from cryogenic applications and ending at high temperature applications at eh limits of polymer-based materials. The thermal stability is based on the aromatic backbone of the polymer. P84 fibres are classified as classified as non-flammable.	P84 can blend into base materials from other fibres e.g, PPS. It would be interesting if adding the fibre into the garment of which is disposable and electrical.

Name	Website
Polymax	http://www.polymax.tw/sports/default.htm
Description	**How to use it**
Coated and Laminated fabrics and composites. Waterproof/Breathable Polyurethane film for textile laminating-by transfers coating. Thermoplastic Ployurethane film for wide-range of application by blown-extrsion and flat-die extrusion.	The waterproof material also helps me to build my project to be safe, and protect the electronics in the garment.

Appendix B Potential material supplier

COMPANY	WEB SITE	MATERIAL OR SERVICE	ADDITIONAL INFO
LG Chem	http://www.lgoledlight.com/index.do#	OLED Light	
Everest Textile Co.,Ltd	http://www.everest.com.tw/index_us.aspx	Temperature sensing material	
Venture Join International	http://rasmaterials.com/ecos-products/technology.html	Conductive cloth	
AUDACES	http://www.audaces.com/us	Design software	
CMST	http://www.cmst.be/	It has a branch to do the wearable technology of LED light	
jiang yin chenxun elecrical coltd	http://www.chenxunfpc.com/bar33.htm	Flexible circuit board	
DU Pont	http://www.dupont.com/products-and-services/electronic-electrical-materials/flexible-rigidflex-circuit-materials/brands/pyralux-flexible-circuit.html	Flexible circuit material	
topwin	http://www.topwin-cn.com/	Flexible OLED provider.	They only have 1.66 inch flexile OLED
Royole Corporation	http://royole.com/cn/?page_id=48	Super thin flexible OLED	Need to contact
Flex Up	http://flexup.meworks.co	Flexible OLED agency	Need to contact wit Tom
refactory	http://www.refactory.co/	circuit design	It cost 10k-15k to design my project, its too expensive, so they recommend Raspberri Pi and BeagleBone to me

Appendix C Material Comparison

NAME	WEB	PRICE	SIZE	USE	COMFORTABLE
116 Luminous Tex 01 	http://sensingtex.com/116-luminous-tex-sample-01	49,90 €	33x70cm	Yes	Yes
LUMINOUS EL TEX 	http://sensingtex.com/luminous-el-tex	Unknow	unknow	Back up	Not sure
115 LUMINOUS EL TEX 01 	http://sensingtex.com/115-luminous-el-tex-sample-01	14,20 €	200 cm	Yes	Yes
LG Flexiblel light 	http://yaspro.en.alibaba.com/product/60325536114-801987285/LG_Chem_s_new_product_OLED_flexible.html	$284.5/pc	210x50mm	No	No
1.66 " flexible OLED 	http://hksebo.en.alibaba.com/product/60044435510-222170586/1_66_flexible_OLED_lcd_screen_tft_small_lcd_display_for_smart_phone_smart_watch_wearable_watch.html	$48/Piece	1.66"	Back up	Circuit board design needed
Arduino e-ink 	http://www.adafruit.com/products/1316	39.95(out of stock)	2.7"	In prototype	No circuit board design needed
Thermomochromic Ink 	http://www.colourchanging.co.uk/index.php?_a=viewProd&productId=415	£18.99	N/A	In prototype	More fashion design needed

Appendix D User Interest Research

General Information

Your Gender

☐ Female ☐ Male ☐ Secret

Your Education

☐ High School ☐ College ☐ University
☐ Graduate Diploma ☐ Master Degree ☐ Doctoral Degree

Your Age? _____

Your Occupants (Please write your major if you are student) _____

Interest and Behavior

Which type of Phone do you use?

☐ Regular Cell ☐ Android ☐ iPhone ☐ Windows ☐ Other

Which is important for you to buy clothes?

☐ Design ☐ Brand ☐ Textile ☐ Designer ☐ Cost

Do you know about electronic components designing on fashion garment?

☐ Yes | ☐ No

Would you like to buy one garment designed with electronic components? (see the picture)

☐ Definitely Yes ☐ Probably ☐ Not Sure ☐ No

Financial Affordance

How much can you afford on a wearable fashion garment?

☐ US$700 and more ☐ US$300-700 ☐ US$150-300
☐ Lower than US$150 ☐ Other (Please Specify)

Additional Feedback

What is your concern about wearable fashion garment?

_____

_____

_____