Interactive Sample Book (ISB) – An Inspirational Tool for Smart Textiles

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Which responsibilities do designers have? One could claim that designers have the responsibility of cooperating with persons from other fields, in order to create synergies, which can generate new product or service innovations, with high aesthetic as well as functional qualities. In this perspective, important aspects of the design process are the materials and technologies that are worked with. In relation to these, designers need to cooperate with experts from other fields, especially when working with new materials and technologies. Using new materials is a challenge, and one of the situations when cooperation with persons from other fields than the design field can be particularly fruitful. Another aspect that needs to be taken into consideration when working with new materials and technologies are environmental aspects. In relation to this, one could say that designers have the responsibility of minimizing the negative effects these could have on the environment, and of considering not only aesthetic and functional, but also environmental aspects when selecting materials and technologies.

The ISB project is an example of a cross-disciplinary project about new materials and technologies involving designers and engineers. It is carried out by Elisabeth Heimdal as her Master thesis from Design & Innovation, The Technical University of Denmark. Collaboration partners are the design bureau Diffus, textile designer Priya Mani, master student in medialogy at AAU Marija Andonovska and DTU supervisor Torben A. Lenau.

Inspiration to use smart materials

Interactive textiles are still quite an unknown phenomenon to many. It is thus often difficult to communicate what kind of potentials lie within these materials. This is why the ISB project was started, as a practice based research project, with the aim of exploring and communicating some of the possibilities within interactive textiles. The applications for interactive textiles range from medical applications to architecture, and from the fashion industry to costume design. In relation to the sample book, focus will be on texture, lightning and senses in relation to integrated decoration and function primarily to indoor applications.

The result of the project will be a number of interactive textiles, to be gathered in an interactive sample book (ISB), in a similar way as the sample books of wallpapers one can take home from the shop and choose from. In other words, it is a kind of display material, which in a simple manner can illustrate how different techniques and smart materials work. The sample book should display a number of possibilities where sensor technology, smart materials and textiles are mixed to such an extent that the textile can react to different kinds of input from the surrounding world.

The aim of the sample book is to build a bridge between technology and design, and make new technologies and materials more available. The book will function as an inspirational tool for designers, students, cultural institutions and companies who wish to start working with some of the possibilities within interactive textiles. In other words, the ISB should facilitate the following:

- *The generation of ideas:* by making each textile sample fun, aesthetic and surprising, by making it tell a story and stimulate the senses, the ISB will stimulate new ideas.
- *The conviction that smart materials can be used:* by providing a technical insight into smart materials and interactive textiles, it will facilitate their actual use.

The size of the samples will be approximately A2 (42 x 59,4 cm). The instructions to each sample will be very limited, in order to leave the situation open for the user. In addition to the sample book itself a booklet containing more information and explanations about each technology will be provided. The booklet will also include examples of existing applications, contact information for possible suppliers and environmental aspects that are relevant to consider for each material/technology. Each page will also be described in detail in the Master thesis, with advantages, inconveniences, power requirements, potential applications etc.

Smart materials
'Smart material' is a generic term for a material that in some way reacts to its environment (Berglin, 2008). Smart materials can be classified in many different ways, for example depending on their transforming function: property change capability, energy change capability, discrete size/location or reversibility (Addington & Schodek, 2005). Smart materials can also be classified depending on their behaviour and function as passive smart, active smart or very smart (Tao in Berglin, 2008). Another way of classifying them is to look at the role they could have in a smart structure, as sensors or actuators (Berglin, 2008).

The concept development made for the ISB was based on the last mentioned way of classifying the smart materials (as sensors and actuators), and on a systematic matchmaking of these. The choice of smart materials to be included in the matchmaking is based on a previous project, about a stress monitoring t-shirt for Danish soldiers, which gave an overview over existing smart materials (Brandt et al. 2008)

Concepts for 5 interactive textile samples have been developed. The concepts are based on the following sensors: pressure sensors, sound sensors, strain sensors and light sensors; and actuators: shape memory alloys, light emitting diodes, electroluminescent materials, photovoltaic cells, optical fibres, thermo chromatic and photo chromatic inks. It should be mentioned that some materials are both sensors and actuators, such as thermo and photo chromatic inks. More concepts including other sensors and actuators could be developed to be included in the ISB in the future.

Smart textiles and environmental issues
Smart textiles consist of a rather complex structure of materials, which could be hard to justify, and this emphasizes the environmental issues that arise with smart textiles (Berglin, 2008). In relation to design responsibility of considering environmental aspects when choosing materials and technologies, it is relevant to ask: What can be the effects on the environment of designing smart textiles? The term 'environment' here includes both the natural environment and humans.

When designing smart textiles the effects on the environment can arise during production, during the use of the smart textile (e.g. as energy consumption) or as the smart textile is disposed of or recycled. The traditional textile industry is one of the most polluting industries in the world, among other things because of the wastewater it generates (Vandevivere et al. 1998). So what can the environmental effects of a smart textile industry be, when these textiles will have a more complex production process, require more energy consumption in their use phase, and their disposal will be more complicated than that of traditional textiles? These are issues that need to be taken into consideration when designing smart textiles.

One can ask whether it makes sense to have a lighting jacket when this makes it very difficult or impossible to recycle the garment. The value added to the textile by making it smart should be such that it can justify its eventual negative effects on the environment. Environmental effects of smart textiles do not only include the natural environment, but also human health. Little is known about how electrical fields from our clothing or other smart textiles in our daily environment could affect our health.

However, smart textiles do not only have negative effects on the environment. In fact, environmental concerns can be taken care of by smart textiles: they can be used as surveillance tool to protect our health, and techniques that are now made for one time use could be made for repeated use (Berglin, 2008). Furthermore, smart textiles often use new technologies that are more environmental friendly than their predecessors. This is the case for LEDs (Light Emitting Diodes), which require very little power. Another example is photovoltaic cells, which can be used in smart textile products, and which use a renewable energy source: sunlight.

Lena Berglin, PhD and researcher at The Swedish School of Textiles, has defined 4 groups of smart textiles, of which the 4th group has been called the resource smart textiles of the future. She defines this group as the new generation of multifunctional fibres that enable resource saving smart products, where everything is integrated into the fabric. Examples of resource smart materials include textiles

that can purify saltwater and make it drinkable, clean air and keep fabric cold on the outside and warm on the inside. (Andréasson, 2008) This might be the direction to take concerning the design of smart textiles, in order to assume the environmental responsibility.

Inspiration in creative work

In order to understand what is characteristic of the creative work, the ISB should support, an investigation of the role of inspiration in creative work has been made. It is based on literature studies as well as interviews and discussions with two textile designers: Vibeke Rohland and Priya Mani; the latter is responsible for the aesthetic design of the samples.

Creative work is characterised by an inspirational phase, where different impressions from a wide range of sources are used in the process of creating a new product/idea. Sources of inspiration in this phase can be almost anything: physical artefacts, materials, nature, previous work, work from others or actuality events. These different kinds of inspiration sources play an important role in design thinking, and can be used both as definitions of context, as triggers for idea generation and as anchors for organizing a designer's mental representations of designs. (Eckert & Stacey, 2003) The ISB is thought to inspire as a trigger for idea generation.

Studies on the role of inspiration emphasize the multisensory aspect of the inspiration sources (Laamanen & Seitamaa-Hakkarainen, 2008). They also point on physical artefacts as fundamental triggers to the generation of new ideas. It appears that the interaction (visual and physical) with artefacts activate perceptive-sensory abilities and the sensitive-aesthetic judgment of designers. (Stigliani, 2008) Each sample should thus stimulate different senses.

In order to inspire, an artefact should furthermore have a fascination and enthusiasm effect on the designer who interacts with it (Vibeke Rohland, interview, March 2009). Each sample should therefore tell a story, which distinguishes the interactive textile sample from more conventional textiles. Each sample has therefore been given a name out of a storytelling perspective: "The textile that can move", "The textile that has eyes and can blink back to you" etc. This perspective has been taken in an attempt to create fascination and enthusiasm.

The investigation has made clear some requirements the ISB has to fulfil in order to be an inspirational tool:

- *The samples have to stimulate the senses.* This requirement is met by using sensory experiences as inputs and outputs in the interactive textiles. The sensory experiences are as varied as possible.
- *The samples have to create enthusiasm.* This requirement is met by making each sample a storytelling about a textile that can do something traditional textiles can't do, and in a way by giving the textile some "human" characteristics.

Designers work individually or in teams, and the inspirational phase in these two contexts will differ. However, it has been supposed that the requirements mentioned above are valid in both situations.

Inspiration is to some extent dependent on a certain responsiveness for impressions. For something to be inspiring, it requires the person to be, at least to some extent, open for it. This kind of attitude also includes openness towards things one does not necessarily like or feel excited about. (Vibeke Rohland, interview, March 2009) This means that for the ISB to inspire, it not only requires the elements mentioned above, but also a kind of open attitude from the person that is to be inspired by it.

Description of the 5 samples

Environmental and sustainability aspects have not been taken into consideration when developing the concepts for the sample book, as this would have limited the solution space, and made it difficult to represent a variety of materials and technologies. The goal of the sample book is to inspire to design with smart materials. In an idea generation resulting from the interaction with the ISB, it is however desirable that environmental aspects are taken into consideration.

The focus when developing the samples has not been on a high level of integration between electronic components and textile, or on highly advanced technology, but on what the textile can actually do, its aesthetic function. In order to be inspiring for a designer, the samples first have to show what can be done with interactive textiles, and not how. The “how” comes as the next step. In the following, the 5 sample concepts are described.

The textile that can change shape: when the user touches the textile, it changes shape. Depending on which area of the textile is touched, different shape changes will be activated in defined areas of the sample. The expected effect on the user is that he/she sees a textile as something dynamic, organic and three-dimensional. One of the challenges with this sample is to predict the behaviour of shape memory alloys when integrated into textiles. The sample is intended to work the following way: soft switches integrated in the fabric close a circuit when touched, and by this power is supplied to shape memory alloys which then contract. These alloys are sewn onto different kinds of fabrics, which then change shape. Different shape changes can be made, depending on the fabric and the way the wire is attached to it: a flat fabric can lift up to a kind of half-globe; a plissé fabric can vary between different degrees of stretching, or cut out parts of a flat fabric can be lifted up to reveal and underlying material.

The textile that has eyes and blinks back to you: using a UV torch, the user lights on the textile, which responds with different light patterns, depending on where the torch is pointed. The expected effect on the user is that he/she sees a textile as something one can communicate with, and he/she gets a feeling of correspondence between the input he/she makes and the output the textile gives back. The challenges with this sample are the integration of solar cells onto the textile and the creation of connections between the solar cells and the light sources. The sample is intended to work the following way: the light from the UV torch is transformed into power by the solar cells, which each supply LEDs, creating a dynamic light pattern as a response to the UV light from the torch.

The textile you can speak to: as the user speaks or sings, or other sound is emitted, light patterns become visible. Depending on the sound, different patterns are made visible. The expected effect on the user is that he/she sees a textile as dynamic and sensitive to external stimuli (in this case, sound), and able to transport one kind of sensory input to another kind of sensory output. One of the challenges with this sample is to create light patterns with different light intensities. The sample is intended to work the following way: a sound sensor is connected to a microcontroller, which decides which light pattern to activate, depending on the sound frequency. The light patterns are made of electroluminescent wires embroidered onto the textile or integrated in other ways into the textile.

The textile that has memory: by pulling elastics on the textile, light and heat patterns are activated. How much light and heat is activated depends on how hard the elastics are pulled. When the user stops pulling, the heat and light disappear, but the effects of his/her action are still visible on the fabric in the form of colour change. The expected effect on the user is that he/she sees a textile as something that is able to remember. One of the challenges with this sample is to find or develop a suited strain sensor. The sample is intended to work the following way: the strain sensor, coupled to a microcontroller decides how much light or heat is generated in different areas of the sample. This light or heat then changes the colour of the fabric in a given area, using photo chromatic or thermo chromatic inks.

The textile that notices you are there: moving the hand above the textile creates a sound and lightning response from the textile. The expected effect on the user is that he/she sees the textile as something that has characteristics in common with humans. One of the challenges with this sample is connecting the different sensors to the actuators (the optical fibres and the miniature speakers). The sample is intended to work the following way: photo resistors placed on different spots on the fabric register the presence of a hand at a certain location, and trigger the emission of light and sound on the given location.

Success criteria

Several criteria can be defined to evaluate whether the ISB project has been successful or not. A first criterion is that the ISB actually works as it is intended to. This implies that the different samples are

able to work the way they were thought in the concept development, and that they produce the intended response to a given input. A second criterion is that everyone in the project team accepts the result of the ISB project, and thinks that the samples live up to the expectations, and that the resulting sample book fulfils the aim of the project. A third criterion is that others (designers, students, cultural institutions and companies) find the ISB interesting and useful if they want to start working with interactive textiles.

A final success criterion is that the ISB is able to inspire and trigger the generation of new ideas. To evaluate whether this is the case or not, two things will be done:

- The ISB will be presented at a cross-disciplinary workshop in Strasbourg with the theme "Body, Space, Movement", which gathers students and faculty from different design and architect educations in France and Denmark.
- A workshop with the ISB will be held with a group of textile design students at the Danish Design School.

In each of these two cases, a plan for how the ISB should be presented will be used. The sample book should be staged in order to test if it can function as it is intended to. If the ISB is simply shown and demonstrated, without a clearly defined setup, little feedback will actually be provided. What kind of reactions can be expected and should be noticed when someone interacts with the ISB? Which reactions can actually show that the user finds the sample book interesting, and that it creates a fascination? These questions need to be investigated further. Both observations during the interaction of the user with the book as well as an interview afterwards, could be used to see if the last success criterion is fulfilled.

At the workshop in Strasbourg the ISB will be presented in plenum, to all the participants of the event, and it will also be the theme of a smaller workshop organized by Diffus, with a more limited number of participants. This will be an opportunity to see if the participants find it interesting, and if it inspires them to take the materials further into new concepts. The weeklong workshop is planned to end in an exhibition/performance, and the task given within the framework of the workshop will therefore be used as a task in which the ISB can be used as inspiration source.

At the workshop with the textile design students, the ISB will be presented and the students will be able to experiment and interact with it for a while. Thereafter the students will be asked to develop ideas and concepts for a textile product for a given context. This could for example be a room divider for a hospital, or a wall decoration in an open office environment. Finally, short interviews with the students will be made.

Project partners

Elisabeth is educated as textile engineer from Borås, Sweden and has previously been working with smart textiles as part of her study. Projects about smart textiles include knitting with optical fibres, and developing a stress monitoring system for Danish soldiers.

Diffus is lead by architect Michel Guglielmi and art historian Hanne-Louise Johannesen. They have throughout the latest years worked with the subject "interactive textiles" in different contexts. Latest in an installation at the Karen Blixen Museum "En fantastisk fortælling" (22/08-2008 until 9/11-2008) and a performance called "Costume Choreography II" shown at a festival in Instanbul (15/11-2008) (see ***Figure 1***).

Torben Lenau, who is supervisor on the project, is Associate Professor at the Department of Management Engineering at DTU, and has a broad experience with materials, among other smart materials and their use in product development. He has worked on The Beetle project, which investigates and tries to imitate the colourful surfaces of beetles, and has developed the material website www.designinsite.dk.

Priya Mani is a professional Indian textile designer, based in Copenhagen. Trained at the NID (National Institute of Design) in India, she runs her own design studio in Copenhagen and consults with

manufacturers in India and Thailand. Her work ranges from experimental techniques to more mainstream design for fabric production.

Marija Andonovska has a BSc in medialogy at Aalborg University – Copenhagen, has studied two years of multimedia design at Odense Technical School, and is now making her Master thesis in Medialogy at Aalborg University – Copenhagen.

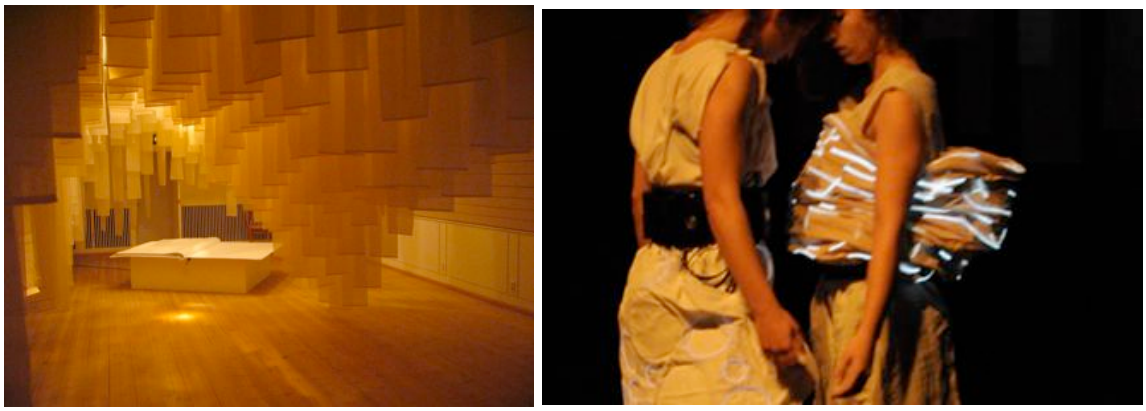

Figure 1 Left: *The interactive installation "En fantastisk fortælling" at the Karen Blixen Museum. The installation is a poetic space circling around an over dimensioned book (1,5 x 2 m) where the action of the visitor mixes with Karen Blixen's stories and her role as "the storyteller".* ***Right:*** *Interactive dance performance at the "Amber08 body-process art festival" in Istanbul in 2008.The costumes with embedded light patterns made of electroluminescent materials react to each other's proximity or distance. The distance is evaluated with built-in ultrasound sensors. Four zones of proximity were defined, with each their patterns language.*

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