

Crafting sustainable smart textile services

Citation for published version (APA):

Kuusk, K. (2016). *Crafting sustainable smart textile services*. [Phd Thesis 1 (Research TU/e / Graduation TU/e), Industrial Design]. Technische Universiteit Eindhoven.

Document status and date:

Published: 18/02/2016

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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CRAFTING SUSTAINABLE SMART TEXTILE SERVICES



Kristi Kuusk

Crafting sustainable smart textile services

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Crafting sustainable smart textile services

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de
Technische Universiteit Eindhoven, op gezag van
de rector magnificus prof.dr.ir. F.P.T. Baaijens, voor
een commissie aangewezen door het College voor
Promoties, in het openbaar te verdedigen op
donderdag 18 februari 2016 om 14:00 uur

A catalogue record is available from the Eindhoven University of Technology Library
ISBN 978-90-386-4020-4

Title	Crafting sustainable smart textile services
ISBN	978-90-386-4020-4
Graphic design	Kerstin Zabransky
Cover	Kerstin Zabransky
Copy edits	Terry Lavender

PhD thesis Eindhoven University of Technology, Eindhoven, the Netherlands

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door

Kristi Kuusk

geboren te Pärnu, Estland

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Het onderzoek of ontwerp dat in dit proefschrift wordt beschreven is uitgevoerd in overeenstemming met de TU/e Gedragscode Wetenschapsbeoefening.

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ACKNOWLEDGEMENTS

This thesis is not the result of an individual journey. It is a collection of shared efforts and experiences. I would like to express my gratitude to the people without whom this work would not be in your hands.

To the **committee members**: thank you for the helpful questions and comments to improve the work. Your thoughtful feedback is greatly appreciated.

Stephan, I'd like to thank you for making the Creative Industries Scientific Program (CRISP) Smart Textile Services project possible and believing that I could contribute to it. When we first started off with you, **Geert Langereis** and **Kees Overbeke**, I really had no idea what I was getting into. You and Geert helped me to start trusting the inner voice – intuition, get guided by it, and let the research direction be inspired by it. Thank you for always showing me the value of personal experiences, and for being there from the start to the end.

Oscar, thanks for your irreplaceable energetic and passionate daily guidance for the PhD project. You really stretched and redefined my limits. Your prompt comments puzzled and clarified, faded and sharpened my understanding and thinking continuously. You opened many doors that I would have never dared to knock and made me learn a lot about myself.

Ron, I greatly appreciate your kind support, encouragement, and focus on guiding the PhD work towards finalising the writing. Your clear vision and result-oriented way of working brought us to the goal! Thanks for joining us in such a critical moment.

This thesis would not be possible without the support and effort of **craft and sustainability experts** sharing their thoughts on my projects. Thanks for taking the time and enriching my understanding with your knowledge Katrin, Marit, Mirje, Nithikul, Tuulia, Alastair, Andreas, Mika, and Nancy.

I would like to thank all the people and institutions involved in **CRISP** who made it possible to share this journey with a large community of design thinkers and practitioners. Special thanks and gratitude goes to **Smart Textiles Services project partners**, orchestrated by Oscar. Scientific partners: Eindhoven University of Technology, Delft University of Technology, the Design Academy Eindhoven and Saxion University of Applied Sciences; Industry and Societal partners: Audax Textiel Museum, V2_, Waag Society, Modint, Contact Groep Textiel, Unit040 Ontwerp, Metatronics and De Wever.

The rich portfolio of smart textile services has the face of all the **partners involved in the projects**. Without you, the design projects wouldn't be what they are today! Thanks, Leon, Guido, Frank, Nico, Wouter, Castor, Kerstin, Martijn, Jesse, Paula, Admar, Eunjeong, Chet,

Marjan, Jussi, Angelina, Roos, Gyula, Lucas, Sabine, Gordon, Ioana, Michal, Mili, Mukesh. Thank you, Christine, for playing with Bedtime Stories Little Red Riding Hood edition with your family on the photos.

I would like to thank the inspiring colleagues in **DQI, Wearable Senses (WS)**, and elsewhere making my days at the university enjoyable. Martijn – the countless discussions and brainstorming we had while co-working, driving, rushing, arranging events, relaxing, attending conferences, workshops, company visits etc., were essential to keep going. It was a pleasure to work side by side with someone as knowledgeable, kind, and sincere as you. Jesus, thanks for all the shared swims, lunches and crazy thoughts about life. Thanks for keeping the WS spirits up Carl, Michel, Brandon, Troy, Pauline, Marina, Simone, Maarten, Paola, Lilian & the WS students with all your inspiring projects and questions. Rafaela, obrigada por manter os meus níveis de vitamina com seus deliciosos sucos frescos.

Thanks for sharing your thoughts and making me feel home during my visiting semester in **Aalto School of Arts and Design** the colleagues at NODUS Sustainable Design Research group.

Thank you, **Kerstin**, for making this dissertation into a beautiful book. **Terry**, thanks for taking care of the grammar and language of this thesis.


I am grateful for the warm connections with **friends** with whom our journeys crossed in the Netherlands. Aida – thanks for introducing me to the crochet nights! Brenda, Guille, Hanne, Dominika, Jesus, Mymza, Eric, Karina, John, Rubina, Naza, Alexey, Carolina, Daniel, Gordon, Ioana, Francisco, Ale, Elton, and Leanne – thanks for being part of the Sunny Sunday story, for being my family in Eindhoven! Alvise, grazie per essere la mia casa.

Last but not least, the **family** keeping Estonia a warm place to return always: Linda, Lauri, Berit, Taavi, Katrina, Maris, Reilika Kristjan, Kristiina, Kermo, Kärt ja teised sõbrad – olete mu inspiratsioon, loovuse ja päikese allikad.

Ema ja isa – tänan teid selle elu eest.





 Scan the image with the Textales LRRH app!

CHAPTER

1

This first chapter shares my personal motivation that has brought me to work at the intersection of crafts, sustainability, textiles and technology. It will be told as a story, through which I clarify key notions, such as culture and craftsmanship, fashion and clothing, sustainability, smart textiles and services that will be used throughout this dissertation. The chapter frames the relevance of the research and design work through the personal motivation and the state of the art of smart textiles in relation to crafts and sustainability.

THE BEGINNING 1.1

When a typical garment pattern is cut, 15% of the fabric is considered to be waste (Rissanen, 2005). My parents started a sewing company in our home in 1991 – for eight-year-old-me it was great! I could find left-over fabric pieces and turn them into new doll clothes with my antique Kayser hand crank sewing machine (L. Best & Best, 2007) from the 1960s. As I recall, all the textile scraps that had fallen to the ground had to be saved and organised by colour and type and put to some creative use. We lived as a family of four in two rooms, on the second floor of a small woodstove-heated house. There was not a lot of storage space. However, my drawer was always packed with textile scraps. It did not take long until I started to bring the left-over fabrics to my elementary school for other girls to craft with. My parents' company grew and so did the piles of fabric scraps, and my frustration at seeing them ending up in the landfill.

My proposal for my MA thesis, when entering the Estonian Academy of Arts, was to develop systems and set up collections for using left-over materials from production companies in the area. I proposed different uses for the scrap material that gets thrown away before ever being used. I wanted to design garments starting from the shape of the left-over pieces, bring some materials to elementary school handicraft lessons, fill objects with the smaller pieces, etc. During my studies, I realized that however hard I worked to do all this, it was never going to solve the larger problem of why all the waste gets generated and disregarded. I found from literature that not only do the scrap fabrics from production get thrown away, but also enormous amounts of pre-consumer garments are destroyed before being worn (Matevosyan, 2014). I learned about consumer habits and the amounts of textile waste generated all over the world in the different steps of the textile and garment life cycle, the environmental and social challenges that textile contributes to. After learning about the existing realm of fashion design and how technology already influences and could even more radically change its course, I started to explore ideas for possibilities that lay in the future, that have the potential to direct how garments are envisioned, designed, constructed, worn and disposed.

Today, of course, there are creative solutions for how to design textile products by generating less waste. For example, approaches such as fully fashioned (Clothing Study, 2015), where the right shapes of material are originally knitted, felted or woven, and zero waste or jigsaw puzzle patterning (Mcquillan, 2015), where the pieces only fit together in one way as a puzzle, are very promising. These solutions, however, do not dominate in the garment design and production fields. Despite the available approaches that are being used and experimented with, most garment production today follows the cut and sew method where the fashion designer sketches the design of woven, knitted and non-woven fabrics. The pattern maker makes a pattern for the design and the marker maker creates the layout for cutting different sizes with minimal use of the fabric using paper or digitally. After all the product pieces are cut and sewn together, it is

possible to make other smaller products out of the space in between the original pattern assuming they get cut at the same time. “However, in the overall picture of sustainability, arguably it is better to avoid waste than to fill the planet with things made from it” (Rissanen, 2005, p. 3). According to Rissanen (2005), “In terms of fabric waste creation, the himation, chiton and peplos of ancient Greece, and the sari of India are perhaps the most ideal. Each is a rectangle of fabric with no cutting, draped on the body” (p. 4).

Garment production led by fashion cycles is part of a much larger consumption system. The general economic mindset is guiding businesses to strive towards growth at any cost. Nature and people are being exploited in many steps of the garment life cycle to achieve higher turnover numbers and larger profit. Dangers of this have been already pointed out in 1972 by the global think tank Club of Rome in the report “Limits to Growth” (Meadows, Meadows, Randers, & Behrens, 1972). Measures have been taken to tackle these issues. However, as mentioned by Thackara (2014), the symptoms of social and environmental harm caused by industrial systems have been addressed instead of the principal cause of the economic system that depends on continuing growth in a finite world. Talking about the changing systems, Thackara (2014) gives hope for the efforts done so far not being in vain: “In an age of networks, even the smallest actions can contribute to transformation of the system as a whole - even if none of us had that outcome explicitly in mind” (p. 3).

My main concern and insecurity as a designer lies in the responsibility of bringing more concepts and ideas in their physical manifestation into the world. Are they really needed? Can they harm people or the world instead of bringing the envisioned benefits? What kind of textile products would support sustainability instead of creating additional problems for it? What kinds of systems would allow the cradle-to-grave mindset to be replaced with the cradle-to-cradle one? How to fundamentally change the way garments are made, sold, worn and disposed? Where to start?

I like the way the mind quiets down while holding crochet or knitting needles or sewing with the machine, stitch by stitch. Seeing hand skills as essential to living, Gandhi and Attenborough (1982) speak about daily life: “Literary education should follow the education of the hand - the one gift that visibly distinguishes man from the beast. It is a superstition to think that the fullest development of man is impossible without knowledge of the art of reading and writing. That knowledge undoubtedly adds grace to life, but is in no way indispensable for man’s moral, physical or mental growth” (p. 5). I would like to learn more about the hidden meanings that emerge from the crafts practise and to make them part of the design process. I turn to crafts and craftsmanship to use the power of thinking through making and to start with something that can be tried out by myself. I do that by developing three directions for smart textile projects, that will be explained in Chapter 2: Portfolio. The way they have been developed and used as a carrier of knowledge in the Research through Design (RtD) process will be explained in Chapter 3: Designing with craft inspired smart textiles.

1.2 CULTURE & CRAFTSMANSHIP

“Culture is the means through which people create meaningful worlds in which to live” (Kawamura, 2004, p. 32). It is the characteristics and knowledge of a group of people, defined by everything from language, religion, cuisine, social habits, music and arts (Zimmermann, 2015). More specifically, “Material culture provides in sum a picture of what human beings are capable of making” (Sennett, 2008, p. 15).



Figure 1 Kihnu folk costumes, ERM EJ 415:26, Eesti Rahva Muuseum, <http://muis.ee/museaal-view/729731>

Kettley (2010) defines “Craft as something that is fluid: as a process, as an object and as a cultural frame” (p. 14). Each culture has their craftsmen. According to Sennett (2008), “Craftsmanship names an enduring, basic human impulse, the desire to do a job well for its own sake. Craftsmanship cuts a far wider swath than skilled manual labor; it serves the computer programmer, the doctor, and the artist; parenting improves when it is practised as a skilled craft, as does citizenship” (p. 20). Also Adamson (2007) analyses craft as an approach, an attitude, or a habit of action. “Craft only exists in motion,” he says. “It is a way of doing things, not a classification of objects, institutions, or people” (p. 4).

Craftsmanship

Estonian textile crafts (Figure 1), which are the starting inspiration for this work because of my cultural background, are documented in various forms of artifacts that embed the qualities rooted in crafts at various levels. The most extensive overview of Estonian folk costume is given by Kaarma and Voolmaa (1981) in a book illustrated with beautiful visuals and patterns accompanied by instructions and markers to prepare the garments, pattern sheets and photographs. Pupart (2011) gives a fresh overview of the traditional Estonian folk costume with examples of the use of ethnic elements in designer costumes.

Adamson (2007) describes craft in some ways being analogous to the term “colour.” “Just as every object must be made in some way, and hence could be considered in some sense to be crafted, every object has colour. When one says that an object is colourful, this is not taken to mean that other objects lack colour entirely; similarly, when we say that something is highly crafted, we are distinguishing it only in degree, and not in kind, from other things that have been made” (p. 1).

According to Sennett (2008), “All craftsmanship is quality-driven work” (p. 24). Also, for Gama-che (2012) craftsmanship is about quality, passion and, experience. “Craftsmanship is doing what you love and doing it right.” In this work, I adopt the view of a craftsman, as stated by Sennett (2008), representing the “special human condition of being engaged” (p. 20). As he puts it, “The craftsman is a more inclusive category than the artisan; he or she represents in each of us the desire to do something well, concretely, material consciousness for its own sake” (Sennett, 2008, p. 145).

Later in this work, I will introduce a folk skirt originating from an island in Estonia - Muhu, which is well known for the detailed work of the women of the island. Kabur, Pink and Meriste (2010) explain that the driving principle behind Muhu women’s production of domestic textiles was to make one’s clothing as fine as the finest garment of one’s home village, and even a little bit better. Davies (2012) comments on that, saying: “Without the pressures of external commercial markets, the women of Muhu simply competed among themselves to produce domestic textiles of ever-more glorious variety, ornament and colour.”

Muhu

Craft items carry stories. Through the hand-made objects people could share information, also the kind of information not allowed or not possible to put into words. A scarf worn over time absorbs the smells, it evokes memories of special time, it carries marks that tell stories and no matter how old it gets, it is still worn because of something more than the function or aesthetics of the scarf; people wear the memories the scarf has gathered over time (Tharakan, Okude, & Cheok, 2010). Mittens were believed to have great protection power that was supposed to keep the wearer away from hostile people or energies. That is why even in the summer, the mittens were placed on the belt (Figure 2), when arranging important matters (Puppart, 2011, p. 60).

Stories



Figure 2 Kuusalu county and North Estonian folk costumes, ERM EJ 415:12, Eesti Rahva Muuseum, <http://muis.ee/museaalview/732317>

Crafts celebrate the skilled hands working directly with the material. As mentioned by Sennett (2008), “Technique considered as cultural issue rather than a mindless procedure. A technique for conducting a particular way of life” (p. 8) or Trotto et al. (2009), “Work created with the hands gives birth to new ideas” (p. 13). Also according to Adamson (2007), “Craft always entails an encounter with the properties of a specific material” and “Craft involves direct engagement with specific material properties” (p. 39). Today, to be able to focus on creating something loop by loop, completely becoming part of that activity, with all the attention-investing time, is a rare opportunity. Therefore, such reflection and sharing time could be seen as an important part of modern well-being or even as luxury.

Traditionally, craftsmen were seen as innovators in a community (Tharakan et al., 2010). It is no wonder that crafts have changed and keep changing continuously. In addition to traditional crafts, which require a lot of time and attention to learn and to practise, there are a lot of new and modern techniques easily related to crafts and craftsmanship views. For example, Fab Labs (Fab Foundation, 2015), which makes digital fabrication tools accessible for the public, could be compared to artisan workshops, only instead of a master passing the skill on, there is a whole connected world of information and like-minded peers picking up challenges together.

Innovators

Craft being innovative yet close to culture and material becomes a starting point for this research into new technologies in textiles. I propose crafting smart textile services to be a meaningful direction for achieving ecological, societal and economical sustainability in textiles and apparel areas. The notions and values related to crafts and craftsmanship will be discussed further in Chapter 4: Craft qualities. Due to my background and motivation to work with crafts and clothing, I will next focus on the textile craft and how it has formed in the process of industrialization.

TOWARDS INDUSTRIALLY PRODUCED TEXTILES 1.3

As the 18th century craftsmen held a very specific attitude towards detail, individualization and quality (Sennett, 2008), nothing was wasted. When garments were crafted in each home and village for their community use, they also carried the warmth of the maker and meaning with them. Long winter nights spent knitting were not only about new socks and mittens, they were as much about social sharing, discussions and life lessons. All clothes had exceptional quality and a clear trace back to the maker. Textiles were embedded with layers of meaning from the environment and the maker, the community and society around them. The meanings of images on textiles is beautifully demonstrated by Green (2008) based on Cambodian pictorial textiles with Buddhist, end-of-rainy-season, funerary, marriage and ordination themes. Green (2008) explicitly notes that “The purpose of pictorial images in whatever medium was not simply decorative” (p. 28). The visuals communicated information and feelings between people, times and even different spiritual realms.

Some values embedded in crafts had to be neglected when moving towards industrialization. The care taken in creating a fabric stitch or a loop at a time was previously seen as one’s ability to craft the life itself. With industrialization, some of those values were lost and replaced with others. Bauman (2011) illustrates the pre-industrial way of living transforming into modern society as follows: “These rules for life, entrenched in tradition, were becoming a hindrance rather than a help in the new conditions. It did not matter that under other conditions, now receding into the past, they had helped people to live in a spontaneously created, but change-resistant, atrophied and corroded society: now these rules were turning into ‘superstitions’ and

'old wives' tales' becoming a burden and the main impediment on the road to progress and the full realization of human potential. It was therefore first and foremost necessary to deliver people from the yoke of superstitions and old beliefs, in order then to be able, through education and social reform, to fashion them according to the dictates of reason and rationally designed social conditions" (p. 52).

Many aspects of life changed due to changes in society and technology. Postrel (2015) explains how technology has developed as part of the story of textiles, how sailors discovered strange areas in the quest for fabrics and dyestuffs, how the Industrial Revolution, before railroads or automobiles, started with the spinning jenny, the water frame, and the thread-producing mills in northern England. Her essay shows from the historical perspective how "textiles are technology, more ancient than bronze and as contemporary as nanowires." The transition into new manufacturing processes completely changed the lives of people moving to cities, including the way they made, used and disregarded clothing.

Textile and fashion industries are going through a paradigm shift. In the 19th century the great part of the garment production in Europe moved from craft to industrialized mass production. The transition happened largely due to the development of technology and processes used within the garment industry. The production efficiency improved exponentially. Instead of a tailor preparing few dresses over a week, a factory of 50 employees is now able to produce 6,000 dresses per month (A. Kuusk, 2015). Certain wastefulness became part of the culture, as the consumption pace did not entirely follow the production capacity. To produce more clothes in less time became the value and norm towards which to aim. The resulting way of making and using clothing nowadays has a lot to do with trends-driven fashion in the garment industry.

Textile

Fashion

Clothing

1.4 FASHION & CLOTHING

Fashion exists in different areas of people's lives and plays an important role in shaping consumer culture (Sassatelli, 2007). In this work I use the definition of fashion from Pan et al. (2015) as "the symbolic, aesthetic, and cultural meanings that objects carry, especially the ways in which people use objects to express their taste, lifestyle, social status and belonging to a community" (p. 53). Kawamura (2004) brings out the conflicting elements of fashion design as the clothing attempting to balance two contradictory aims: it focuses our attractions and at the same time protects our modesty.

Kaiser (1996) defines fashion as a symbolic product, which meaning is controlled by time. Kawamura (2004) proposes a distinction between fashion and clothing: "Fashion is produced as a belief and an ideology. People wear clothes believing that they are wearing fashion because it is something considered to be desirable. Clothing production involves the actual manufacturing of fabric and shaping it into a garment" (p. 88). Armstrong et al. (2014) support this: "Clothing, considered distinct from fashion, is a material product that meets a physical need for protection and function. Fashion connects consumers' personality to external symbols" (p. 31). I recognise that the consumption of clothing is driven by fashion that is part of the contemporary culture. However, in this dissertation I focus on textiles and clothing and not the fashion directing them.

"Fashion trends are created, promoted, and discarded" (Aus, 2011, p. 15). That has led to fast fashion as a concept dominated by consumer culture with fast changing trends, and low quality, leading consumers to buy more clothes because they are affordable but discard these after only one season (Fletcher, 2008). Fast fashion completely opposes the craftsmanship approach.

"In fast fashion, economic factors dictate the production process. Both the manufacturer and the consumer are focused on only one phase in the product life cycle – the sales transaction. A garment's value lies in its cheap price. Achieving this low price requires low priced inputs – including cheap raw materials, cheap labor, and fast production. The result of fast fashion is that the value of a product lies no longer in its quality, but rather its cheapness" (Aus, 2011, p. 27). The promotion of fast fashion contributes to the creation of more waste, and forces the fashion industry to rethink the system. "With any luck, what we will realize is that making waste is not the problem we must solve. If a living species does not generate waste, it is most likely dead, or at least very ill. The problem we have, and that we must address, is that we waste the waste we create" (Pauli, 2010).

Fast fashion

According to Niinimäki (2011): "The textile and clothing industry is currently one of the largest global industries, and it causes increasing negative environmental impacts during material cultivation, manufacturing processes, many logistic phases and during use and disposal stages. In textile and clothing production manufacturing cycles are speeding up, and hence manufacturing and consumption volumes are ever-increasing while simultaneously the lifespan of products are shortening" (p. 16). It makes perfect sense for the growth-driven economic models of fashion design to speed up and to have as many garments bought daily as possible. The producers need to produce more units in shorter time in order to match the requirements set by the designers, following consumer behaviour. Unfortunately, "while the continual development of new garments may make economic sense to fashion producers, it is ultimately destructive to society and the environment" (Gwilt, 2015a, p. 63). On the brighter side, the need for a fundamental change in the system is unavoidable. However, what is sustainable when it comes to clothing consumption, and how to tackle the complex topic of sustainability in this context?

APPROACHES TO SUSTAINABILITY 1.5

Sustainable consumption has previously been explained by at the Oslo Symposium by the Norwegian Ministry of the Environment (1994) as "the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations." A reduction in the throughput of resources is seen as the solution for industrialized countries (Cooper, 2005). In the present context, Cooper (2005) says that, it means slowing down the rate at which products are consumed by "increasing their intrinsic durability and providing careful maintenance" (p. 54). The idea of reduced throughput of products and services becomes less appealing in case it leads to rising unemployment and recession in society. However, according to Cooper this can be overcome by increasing product lifespans manifested both through efficiency and sufficiency. He is referring to the effective use of materials in combination with slower throughput as an interesting approach. Cooper (2005) also points out that craft-based, highly skilled production methods together with increased repair and maintenance work may provide employment opportunities to overcome the reduced demand for new products (p. 55). All in all, it is only possible to consume sustainably if the products last longer.

Sustainable consumption is part of a larger sustainability approach. As pointed out by Lumsden (2003) based on Boyle: "Sustainability is achieved when an activity can be continued or sustained indefinitely without damage to the fundamental global system of the environment and the human social condition" (p. 4). According to the World Conservation Union, "Sustainability is the path that allows humanity as a whole to maintain and extend quality of life through

Sustainability

diversity of life” (Adams, 2006). “The concept of sustainability is based on the premise that people and their communities are made up of social, economic, and environmental systems that are in constant interaction and that must be kept in harmony or balance if the community is to continue to function to the benefit of its inhabitants - now and in the future” (Monday, 2001). Pauli (2010) provides another way of seeing sustainability, describing it as the capacity to respond to the basic needs of all, with what is available.

Environmental sustainability

Environmental sustainability is defined by the Commonwealth Government in Australia as “using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased” (Ecologically Sustainable Development Steering Committee, 1992). Meadows et al. (1972) articulate how people have been applying technology to the natural pressures that the environment exerts against any growth process. They point out that it has been “so successful in the past that a whole culture has evolved around the principle of fighting against limits rather than learning to live with them” (p. 150). Societal sustainability is defined by the United Nations as “meeting the needs of current generations without compromising the future generations to have their needs met” (World Commission on Environment and Development, 1987). Therefore it’s really about much slower growth, and in some cases no growth or negative growth (Meadows, 1999). Economic sustainability is about long-term profitability and sustained earnings. Nieto (1996) approaches ecologic progress as damaging environment and human life and therefore doesn’t consider it as real progress. Economic means should serve the social and ecologic needs not the other way around. According to the Business Dictionary, “economic sustainability involves using the assorted assets of the company efficiently to allow it to continue functioning profitability over time” (Business Dictionary, 2015b). In the experience economy, “While society changes its focus from “well-fare” to “well-being,” design becomes increasingly interested in the question whether it can design for happiness” (Hassenzahl et al., 2013, p. 21).

Societal sustainability

Economic sustainability

Holistic sustainability brings the previously described notions of sustainability together with a greater emphasis on responsibility. “Understood in a holistic form, sustainability is a complex and multifaceted vision of development. It is a multidimensional model of development which limits economic growth and other human activities to the capacity of nature for self-regeneration, places the improvement of the human condition (social and human development) as its primary goal, and places respect for environmental quality and the limits of nature at the core of any economic, political, educational, and cultural strategy” (Nieto, 1996). The holistic approach to sustainability values development that is intended to sustain life, the human condition and values, and the balance of the systems of nature (Gwilt & Rissanen, 2011). It challenges the current notion of progress oriented to (economic) growth (McDonough & Braungart, 2002; Meadows et al., 1972) and basically suggests fundamentally restructuring the present society. Klingmann architects and brand consultants say how in holistic sustainability, social, environmental, cultural, and economic factors combine to positively reinforce each other to increase the quality of life of an area (Klingmann, 2010).

Holistic sustainability

Quality of life

Quality of life indicates the general well-being of individuals and societies. “It is a broad concept that encompasses a number of different dimensions (by which we understand the elements or factors making up a complete entity, that can be measured through a set of sub dimensions with an associated number of indicators for each). It encompasses both objective factors (e.g., command of material resources, health, work status, living conditions and many others) and the subjective perception one has of them. The latter depends significantly on citizens’ priorities and needs” (Eurostat, 2015). The quality of life combining objective and subjective indications is very specific to each community. “Through the deliberate and active engagement with the world,

people can—at least to some degree—take control over their experiences and, thus, make themselves more (or less) happy” (Hassenzahl et al., 2013, p. 21). Local solutions of global matters can go a long way. “Although it adopts a broad perspective, in practise the pursuit of sustainability is fundamentally a local endeavour because every community has different social, economic, and environmental needs and concerns. And in each community the quality, quantity, importance, and balance of those concerns is unique (and constantly changing)” (Monday, 2001).

Garment creation, production, selling and maintenance cycles running in full speed as part of the consumer culture seem like the least likely areas to turn towards sustainability. However, the issues tackled in the previously described sustainability approaches touch every single individual, as does a cloth – it protects and covers people nearly all the time, whether sleeping or awake. Perhaps the global system literally touching the skin of everybody each single day could play a role in the journey towards a better quality of life for people everywhere. How to tackle the constantly changing needs within different communities? Could something as important to people as clothing drive the way we live towards sustainability?

TOWARDS SUSTAINABLE FASHION 1.6

The Club of Rome pointed out the dangers of population growth in the 1970s (Meadows et al., 1972). In the textile and fashion area awareness of these dangers triggered several approaches. In the 1980s environmentally friendly clothing gained popularity, the 1990s was the time for eco-efficiency and the early 21st century took redesign and multiple life cycle thinking under attention (Niinimäki, 2011, pp. 19-25). While environmentally friendly is meant to be not harmful for the environment, eco-efficiency has the potential for reducing environmental impacts and economic costs simultaneously through more efficient use of energy and materials. Such innovation, though, may not lead to sustainable development as long as consumption continues to increase (Cooper, 2005). Redesign and multiple life cycle thinking actually promote consumption and the change of clothes.

How to design, produce, wear and dispose of clothing more sustainably is an ongoing and active discussion and it is also becoming more widespread to talk about clothing instead of fashion. As trend forecaster Edelkoort suggests in her manifesto, “the economy of clothes will take over from the turnover of fashion” (Dezeen Limited, 2015). She predicts that couture will make a comeback, occupying the void left by fashion: “After all it is in the atelier of couture that we will find the laboratory of this labor of love. Suddenly the profession of couturier will become coveted and the exclusive way of crafting couture will be inspiring all others” (Dezeen Limited, 2015).

Sustainability in textiles and garment production has been covered from different angles. Allwood (2006) gives an overview of the present and future sustainability of clothing and textiles in the United Kingdom. Gwilt and Rissanen (2011) bring out several case studies to think about how people make and use clothes. Armstrong et al. (2014) look into sustainable product-service systems for clothing and explore the consumer perceptions of consumption alternatives in Finland. Fletcher (2008) brings together information about sustainability aspects of fashion and textiles, practical alternatives, design concepts and social innovation. Niinimäki (2011) presents the reciprocation between design and consumption of textiles and clothing. Breuer (2012) gives an overview for designers on how the fashion industry works, how to plan everything related to realizing a fashion collection and what to consider for the future sustainability. Finally, Matevosyan (2014) gives a guide for designers on how to shift fashion from a harming to a contribut-

ing industry. Meantime, the ideas about service economy are activated in fashion research and experimental practise.

1.7 SERVICES FOR CLOTHING

*Sustainable
fashion
design*

*Service
elements*

Niinimäki & Koskinen (2011) point out the elements of proactive sustainable fashion design as continuing satisfaction with the product, the product or service fulfilling the consumer's changing needs, new elements in design and new experience with the product. The most promising sustainable design strategy Niinimäki (2012) finds in the combination of product design with service elements. As mentioned by Gwilt and Rissanen (2011): "Before the Second World War, in Europe and America, clothing was routinely repaired and altered, either in the home or through a service provider. Garments were considered valuable and, mainly for economic reasons, they were regularly repaired. Labour costs associated with repairing were at the time affordable in comparison to the price of new materials and garments" (p. 61). Services also become essential when thinking about more sustainable care-taking approaches. It is during the use phase in the life cycle of a fashion garment that most of the environmental impacts occur (Fletcher, 2008; Gwilt, 2015b). It could make a remarkable impact if all the cleaning, drying and ironing would be done centrally using eco-friendly care products and machinery with lower power consumption. Already, not having a washing machine in individual homes, where it gets used a couple of times a week, would be a great step forward for sustainability.

"This cradle-to-grave model of producing fashion stems from the mid 19th century when a modern fashion industry emerged in Paris, and it continues remarkably unchanged to this day" (Gwilt & Rissanen, 2011, p. 57). According to Edelkoort, "the consumers of today and tomorrow are going to choose for themselves, creating and designing their own wardrobes." "They will share clothes amongst each other since ownership doesn't mean a thing anymore. They will rent clothes, lend clothes, transform clothes and find clothes on the streets" (Dezeen Limited, 2015). It is difficult to relate to most of the products over a longer time period, because the needs and identity of people change. There might be a chance for people to form stronger relationships with products, that adapt their changing needs in a service system, that supports that transformation. Moving from a product-based society to a service based one, the world economy relies greatly on services for labor and value creation. Touchpoints or multiple contacts between service organizations and their clients change the way the industry works (Secomandi & Snelders, 2011).

Sustainability in textile and clothing field will be discussed further in Chapter 5: sustainability qualities. I propose the use of services as an alternative approach towards sustainable garment design, production and consumption. Smart textiles have potential to support the transition towards services. With smart textiles, we have a new market that is still possible to direct. Designers can propose new ways to deal with fashion and textile products for the users, producers and designers, since the whole supply chain of textile and garment production needs to change in order to be sustainable. The path can still be found. Where do the smart textiles come from anyway? What are they and what kind of potential for sustainability do they carry?

1.8 SMART TEXTILES EVOLUTION & EXAMPLES

Smart textiles, also known as intelligent or e-textiles, are different combinations of textiles and technology materials and techniques. Golden and other metallic coated threads have been around and used for embroidery already for more than a thousand years (Harris, 1993).

Electronic components close to the body and textiles date back as far as the 1880s, starting with (as strange as it might sound) the Electric Girl Lighting Company leasing girls wearing electric bulbs on their foreheads and batteries in their clothing to their customers for flexible use of lighting instead of the stationary electric lights in 1880s. They suggested the girl be furnished with either fifty, hundred or just two candle power, depending on the function (lighting the hall, guiding visitors, flexible light for reading) the light would be used for (The New York Times, 1884). "Flash" jewelry from Paris was exhibited in New York in 1884, and included hatpins and brooches decorated with small electric lights mounted like jewels (Marvin, 1988).

Actual computers started to appear close to or strapped to the body in 1950s. Thorpe and Shannon developed the first wearable computer used to predict roulette wheels in 1955 (Thorpe, 1998) and Mann the backpack-mounted computer to control photographic equipment in 1981 (Rhodes, 1997). In those examples all the electronic components were separated from the textiles. The integration between the textile and electronic components became closer and stronger in the 1990s, when another group at MIT started to explore how the electronic devices might be more gracefully integrated into textiles and other soft materials. Orth, in collaboration with Copper and Lockwood for example, developed the Firefly dress and necklace in 1998 merging together metallic silk organza, conductive yarns, conductive Velcro, LEDs, gold beads, silk, batteries and electronics (Orth, 2009).

The smart textiles we know today have enhanced properties compared to traditional textiles. They can be programmed, they react and adapt, sense and change according to certain external behaviour or inputs. According to Köhler (2013b), the term "smart textile" is attributed to the product (smartness), whereas the term "e-textile" is used for talking about the technology (hardware) that realises the smart functionality (p. 5). Van Langenhove and Hertleer (2004) call smart textiles the "textiles that are able to sense stimuli from the environment, to react to them and adapt to them by integration of functionalities in the textile structure. The stimulus and response can have an electrical, thermal, chemical, magnetic or other origin" (p. 63). They also introduce sensors, data processing, actuators, storage and communication in smart textile clothing context.

The differences between the two worlds trying to merge, and specifically between fashion designers and engineers, is brought out by Chang (2005) comparing fashion and technology approaches. However, a lot of inspiring examples emerge and Seymour (2008; 2010) writes about the different projects at the intersection of design, fashion, science and technology with an explanation of the role technology plays in a fabric or article of clothing.

Some people talk about smart textiles in a crafts context. For example, Tharakan (2010) explores how Indian textile crafts would shape the future of interactive textiles and technology. She gives value to the craftsmanship and separates craft items clearly from gadgets. Baggerman (2013) on the other hand looks into the social aspects of crafts in the context of smart textile services. Taylor and Robertson (2014) bring together a digital-craft skills base, disparate expertise of printed textile expertise, and constructed textile and light-emitting optical fibre expertise in Digital Lace.

Köhler (2013b) presents anticipatory eco-design strategies for smart textiles, and looks into the environmental risk prevention and the risk development of the emerging technology. Similarly, Van der Velden (2015) looks into life cycle assessment and eco-design of smart textiles. They approach the sustainability aspects related to smart textiles from the material integration level.

1.8.1 THREE LEVELS OF INTEGRATION IN SMART TEXTILES

Cherenack and van Pieterse (2012) describe the evolution of smart textiles in three phases. “The first category of smart textiles stayed close to the vision of wearable computing—to design a fabric computing platform. An important goal was to design easily reconfigurable interconnect technologies inside textiles using fibers and yarns with a single functionality (e.g., electrical or optical conductivity)” (p. 2). According to them, “This was followed by a second category of smart textiles that exploited various new textile fabrication methods such as embroidery to achieve hybrid smart textiles. In these smart textiles, the fabric generally formed an essential part of the textile device or circuit (i.e., it was more than simply a carrier for textile yarns and circuits). Smart textile design was still approached from a traditional electronic system design level, but more and more functions were achieved within the textile itself” (p. 2). And finally, “The first efforts to create more complicated fiber-level electronics (category 3) started appearing in the early 2000s. This field of research is also sometimes referred to as “fibertronics.” The philosophy behind these research efforts was to create devices and logic circuits “below the device level,” i.e., to achieve higher order electronic functions at the fiber level and implement more sophisticated smart textiles from individual fibers. These research efforts generally focus more on technology development, and systems are built from the fiber upwards (in contrast to the more traditional top-down methods used in previous categories)” (p. 2).

The three levels of integration for smart textiles create a more systematic approach to differentiate between the three project lines that will be introduced in The Portfolio (Chapter 2). Each project line has a different level of integration of textile and technology serving as an example to represent the specific type of smart textiles.

1.8.1 FROM CONCEPTUAL ARTISTIC WORK TO COMMERCIAL PRODUCTS

Smart textiles serve as exploration material for different purposes. They are crafted as one-off pieces to convey a concept. They can be produced using industrial machines, therefore production ready. Some smart textiles products are on the market and being widely used.

Several designers within the smart textile field have focused on crafts and done interesting work in bringing textiles and technology closer to each other through craft techniques to express conceptual ideas. Dijkstra (2015), for example, brings together material explorations in delicate shapes and powerful sculptural fashion items. Hertenberger (2014) and Grant (2015) created delicate Lace Sensor Dresses that integrate pressure sensors made out of lace, and speakers covered with embroidery. Coleman (2009) also appreciates craftsmanship and artistic expression in her work, such as the Holy Dress, a garment that punishes its wearer through an electric shock when a lie is told and Media Vintage, a series of interactive electronic textiles that contain memories. Berzowska and Coelho (2006), in their project Memory Rich Clothing, are looking for more subtle, playful, or poetic aspects of people’s identity and history to redefine some of the assumptions that technology designers traditionally make under financial and cultural constraints about how people interact and communicate with each other. They introduce reactive garments that record and display their history of use and communicate physical memory: Intimate memory, Constellation, Octopus: body-worn interactive modules. Those projects translate the cultural and personal background of the creator through the material to the viewer. They often involve detailed and dedicated work by hand or machines to understand and communicate

the issue in hand.

The latest experimental work of O’Nascimento includes a light reactive bomber jacket that carries 64 3D-printed spikes that light up according to the sound; Recording Shoes, which record and play back noises using steps as a trigger, and a collaborative shoe design from Adidas called “Jump!”, that enables their wearer to leave both a physical and virtual path. “One jump allows a post to Twitter, two jumps take a Google Streetview photo and posts it to Facebook, while three jumps enable the wearer to pin their personal Google map. The shoes are connected to an Android app on the Moto X via Bluetooth and are performed via a tailor-made app” (Popkalab, 2015).

Van Noodren (2015) is merging fashion and technology, crafts and cutting-edge production technologies in her work This Fits Me. It is a system that allows people to design unique and personalised fashion through 3D body scanning and generative algorithms. A virtual garment is generated based on a 3D scan of the body of the customer, who can add a personal touch by customising the generative design of the garment. The work of Toeters is often in collaboration with technology companies and therefore very close to producibility. Her work with Philips Blue Touch (Toeters, 2010) is available in the market. She is also active in the research field and has developed, for example, Drapely-o-lightment (Toeters, 2012), a skirt that consists of six organic light-emitting diodes that are integrated in a fabric consisting of over 2500 patches, that drape according to their composition. The Solar Fiber knitted shirt (Toeters, 2015) is another collaborative work of Toeters, where optical fibers are integrated into the garment during the knitting process. Small photodiodes are connected to the end of the fibers to transform the transported light into electrical current. Her caring workwear, sustainable and supportive garments for nurses (Toeters, 2014) include a posture sensor, a gas sensor, a supportive underlayer and a futuristic pattern design.

The products commercially available in the smart textile field have been refined to every last detail, to ensure their resistance in the hands of a consumer. They tend to depart from the technology side. SensFloor is a large-area sensor system. It is based on a textile underlay and a sensor system with integrated radio module proximity sensors. “The sensor system differentiates between a person standing or lying on the floor and determines the direction and velocity of movements” (SensFloor, 2005). Ojavee (2013) demonstrates interactive soft displays - felt surfaces that sense touch and are able to leave traces by colour change. She works on both installations and products.

In healthcare and body monitoring products, there are two major companies. Clothing Plus (Clothing Plus Group, 2015) has its strength in healthcare medical applications ensuring everything from critical bio-compatibility and non-toxic materials to accurate sensor placement. Clothing Plus set up its production facilities in China where it runs a hybrid mass production of textile-integrated electronics. OM Signal has developed a OM Smart Shirt (OM Signal, 2015) that communicates body measures, such as heart rate, breathing, and stress levels, to the wearer’s mobile phone through silver threads connected to a smart box. OM signal has collaborated with several fashion brands to bring its product towards perfection and larger markets. For example, it developed a PoloTech (Ralph Lauren, 2015) smart shirt with Ralph Lauren.

On the fashion side, the absolute pioneer in conquering the consumer markets is Cutecircuit (2015a), which has been working with fashionable wearable technology since 2004. Its first prototype Hug Shirt (Cutecircuit, 2014) involved a communication aspect, where two wearers could send hugs over distance, by physically sensing them. Cutecircuit’s Prêt-à-Porter line that was launched in 2010 consists of garments with added effect prints, laser-cuts and light.

For example, the K-dress (Cutecircuit, 2015b) is a hand-pleated silk chiffon with hundreds of Micro-LEDs. Cutecircuit works on the Haute couture line as well, which includes detailed and personalised work. For example the Twitter dress (Cutecircuit, 2015a) brings together more than 2,000 triangular Hematite Swarovski elements that create the neckline and back of the dress with animated fabric displaying tweets from the wearer's fans.

Smart textiles hold great potential for enhancing the way people express themselves and communicate to each other. For example, the digital connected future (Kerckhove, 2009; McLuhan, 1964) comes a step closer through the development of smart textiles. They could also play a role in popularizing conceptual fashion (Ilison, 2008) and ethical design (Niinimäki, 2013). As noted by Susanne and Meagan for Fashion Freaks, "Maybe a truly sustainable fashion is the sort that adapts and shifts, changes shape and expression after the individual wearer's needs and wants?" (Gwilt, 2015b, p. 15) I believe the sustainable fashion could be achieved by developing smart textiles towards products and services that shift according to the individual wearer's needs and wants.

Producing a vast amount of low quality garments and sending them into the world has created the current waste problem in the fashion industry. It is very appealing to think about new technologies, how they can help designers to create customized products on demand sustainably. It could mean fewer materials used for creating more value for the user. Due to changing lifestyles, the model of sewing the clothes in the studio of the village tailor doesn't fit today's cosmopolitan world. However, a 3D scanner is able to gather very accurate measurements from the customer. Garment construction software, such as Lectra (2015) or AccuMark in combination with Gerber (GerberTechnology, 2015), allows technical constructors to translate that information into clothing design and grading, markers, that can already be cut and sewn anywhere in the world by a "local seamstress."

This research proposes to develop smart textile services by finding inspiration from the craftsmanship approach (Sennett, 2008) of drive for detail and personalisation. It looks into forgotten values that have been put aside due to industrialization. The work suggests looking at the values found in tradition and rituals, craft techniques and the hands-on approach while developing technological innovations. Perhaps the new interactive garments supporting connectedness between people and communities could guide the development of clothing and textile industry towards holistic sustainability (Nieto, 1996) and better quality of life (Hassenzahl et al., 2013).

The three different lines of smart textile service examples developed within the Research through Design (RtD) process (Frayling, 1993) are carried through three different phases of maturity. They start as crafted items exploring the space between the material and myself and develop towards industrially producible prototypes. As the last step, the prototypes become market-ready samples. Therefore my work bridges the handmade approach, which is used to try out first ideas and build on them, and the efforts towards their commercialisation. The values gained from traditional crafts and the context of sustainability have been embedded into my RtD process by myself and by the surrounding community. I bring together the insights from crafts and sustainability areas and apply them in the smart textile services context.

The projects in Portfolio (Chapter 2) have a strong craft starting point and drive towards sustainability. As stated by Monday (2001): "Sustainability is an ideal toward which to strive and against which to weigh proposed actions, plans, expenditures, and decisions. It is a way of looking at a community or a society or a planet in the broadest possible context, in both time and space." In the RtD process (Chapter 3) I transform sustainability boundaries into borders to

guide the RtD directions and resistance into opportunities to find new areas of exploration. The smart textile services projects aim to give positive impact to society through innovating through traditional crafts. The design work is finding balance between the fast changes of developing technology and traditional slow crafts. In a way, I am looking for the "narratives for smart textiles" (Tharakan, 2011). This research proposes smart textile services as one promising direction for the developing service implementation in textiles. Interactive garments support the need for being connected and sharing.

CRAFT AND SUSTAINABILITY QUALITIES IN SMART TEXTILE SERVICES 1.9

Quality is a trait, character, or feature that someone or something has (Dictionary.com, 2015). In textiles and garment design, quality can refer to a level of character with respect to fineness, or grade of excellence. The overall quality of apparel consists of an item-specific set of qualities, such as: a style they would wear, overall shape on the body, a style they would buy, leg shape style, upper hip area style, overall style, current fashion, overall pleasantness of fabric, fibre content, feel of fabric, weight of fabric, newness, etc. (Fiore & Damhorst, 1992). The set of sustainability and craft qualities of smart textile services shows the overall sustainability and craft characteristics of the design concepts. The general craft or sustainability level of each smart textile service idea can be evaluated by viewing the collections of all found qualities as a whole.

This chapter covered the main notions part of the craft and sustainability qualities in smart textile services. This section provides a focused summary of the main terms in the context of this dissertation. Craft, originally part of a culture, represents the desire in each person to do something well. A craft item is not necessarily handmade, but it carries the stories of time and culture in it. Craftsman is the part in each person, thriving to do a job well for its own sake. (Sennett, 2008) Clothing is a physical material product meeting physical need for protection and function. (Armstrong et al., 2014) Fashion connects people's personal preferences and desires to external symbols. Fashion largely drives the consumption of clothing. Sustainability represents the high quality life experience. It inclusively considers diverse life forms and aspires to extend the overall quality of life. In ecology the term sustainability invites us to maintain the environmental processes on which life depends. In societal view, sustainability advocates for meeting the needs of current generations by not jeopardising the needs of future generations. Economic sustainability suggests long-term strategies that would serve social and ecologic needs. Each community has specific needs to achieve higher quality of life - the general well-being of individuals and societies. By stepping into services instead of mass produced garments treated as part of fashion trends, clothing becomes a local matter backed by global systems and knowledge. Services, defined as the intangible products (Business Dictionary, 2015a), provide an interface between the smart textiles and the user. Smart textiles, as the different combinations of textile and electronic materials and techniques, provide an interesting stand for envisioning services. They trigger interaction, which can be seen as a service or supported by one.

The question arises whether smart textiles could direct garment design, production, use, and disposal in a more sustainable direction. It is tackled through the central research question of the dissertation, what are craft and sustainability qualities and how are they implicitly used in the design of smart textile services? How to make craft and sustainability qualities explicit? If they are explicit, how can we use the qualities in the design process?

Craft

Craftsman

Sustainability

Environment

Societal

Economic

Quality of life

Services

Smart textiles

What are craft and sustainability qualities and how are they implicitly used in the design of smart textile services?

To answer the research question, the work contributes a portfolio of three design iterations in three main project lines that demonstrate the design space for the three different levels of integration for textiles and technology. I share the first-person experience into designing with craft-inspired smart textiles and provide a designer insight into the complexities of combining two separate worlds of textiles and technology together in different levels in multidisciplinary teams. The notions analyzed from the development of the smart textile services in the environmental, societal and economic sustainability views, combined with the craft qualities, provide a design inspiration list for the future development of sustainable smart textile services.

Research through Design (RtD) (Frayling, 1993) serves as an approach to look into craft and sustainability qualities in the context of smart textile services. It is a continuous process of designing and reflecting with an addition of bringing the prototypes and reflections to the communities of crafts and sustainability experts in order to evaluate and deepen the understanding of how they can be applied to the smart textile services context (Figure 3). The RtD approach described in Chapter 3 has been followed with two rounds of craft experts' reviews as shown in Chapter 4, and sustainability experts' reviews as shown in Chapter 5. In Figure 3, in the first loop, the prototyping serves as an inquiry into opportunities for smart textiles. Through the material explorations within the smart textiles area, different directions for the projects are found. In the second two loops, the prototypes serve as inquiries into craft and sustainability qualities. Later, the knowledge gained serves as an input for the re-design of Textales. In the last two loops, the prototypes serve as inquiries for the refinement of the craft and sustainability qualities.

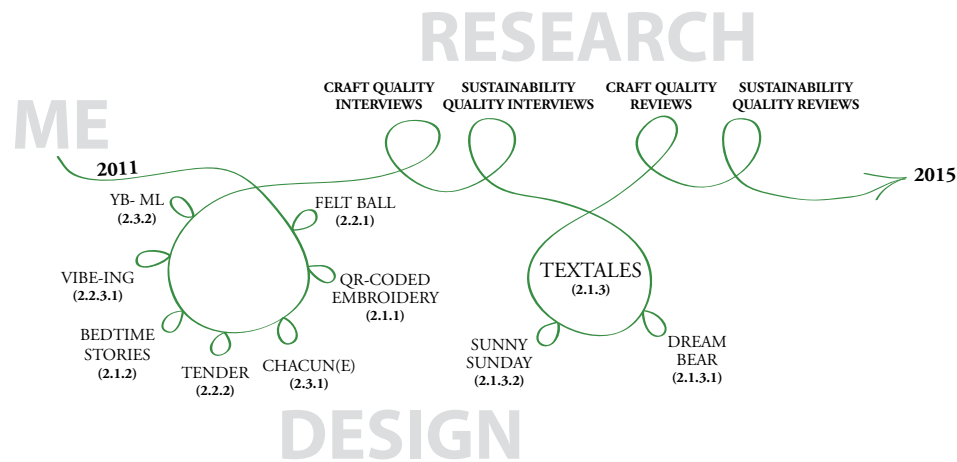
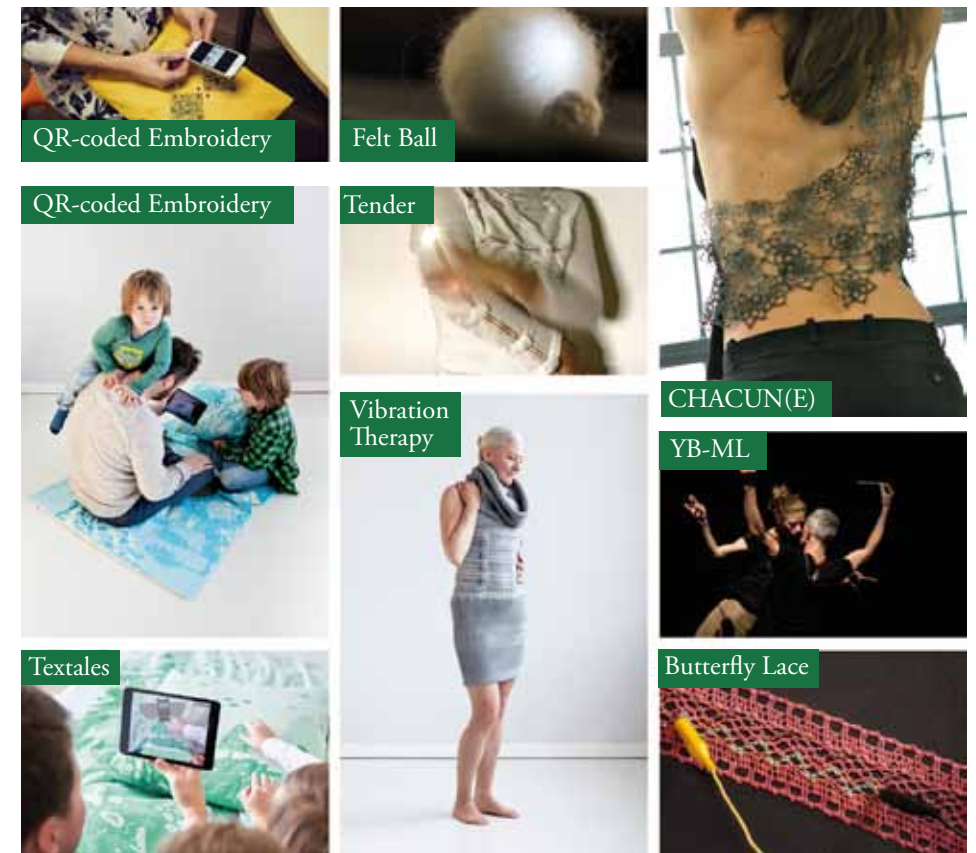


Figure 3 The RtD process showing how the first prototyping cycle feeds information to the craft and sustainability quality interviews, which again gives information as input to the redesign phase, and that again to the craft and sustainability reviews.

During the RtD process my personal cultural meaning is translated into experienceable smart textile service proposals Digital Stories on Textile (2.1), Body Sensing and Actuating Networks (2.2) and Thermocraft (2.3). The craft qualities are identified by looking into different iterations of the Digital Stories on Textile (2.1) projects QR-coded Embroidery (2.1.1) and Bedtime Stories (2.1.2) in comparison with traditional crafts (Figure 4). The sustainability qualities are identified by analysing three smart textile examples: Bedtime Stories (2.1.2), Vibration Therapy (2.2.3) and CHACUN(E) (2.3.1). As the inquiries into both qualities overlap in Bedtime Stories project, it will be re-designed to validate the qualities in the project Textales (2.1.3).



Inquiries into craft qualities


Inquiries into sustainability qualities



Figure 4 Inquiries into craft and sustainability qualities meet in Bedtime Stories (2.1.2) and are both applied to develop the editions of Textales, where the craft and sustainability qualities are reviewed.

To find the craft and sustainability qualities in smart textile services, the collection of three lines of projects going through three iterations each will be presented next in The Portfolio (Chapter 2).



 Scan the image with the Textales LRRH app!

CHAPTER 2

The portfolio explores sustainable smart textile services. The smart textile examples of three design iterations in three main projects emerged during the Research through Design (RtD) process, looking into craft and sustainability qualities. Each iteration builds on the previous one. The research insights were immediately brought into re-design and evaluated again. The portfolio demonstrates the design space for three different levels of integration for textiles and technology. The created design space allowed the different design directions to be tried out and learnt from. The broad exploration phase allowed different ideas to emerge and be refined by my intuition, people involved and facilities in hand.

As described in the Introduction (Chapter 1), my motivation for bringing textiles closer to technology and looking for different ways they could be beneficial to each other started out with a concern for sustainability. During the first steps to explore the different combinations of textiles and technology, I set out to use fashion and the newness of technology to slow down rather than to accelerate consumption in the garment and textile area. I show some of those potential future scenarios for fashion design and garments through the prototypes. In a way, the current chapter presents a manifestation of design challenges. The sustainability challenges are discussed and materialized through and into the prototypes. It is an attempt to create a complementary relationship between the old materials and techniques and the new technologies and ways of thinking by merging them naturally and allowing the emerged combinations to create new dimensions for seeing and working with clothing. It is not the sustainable future, but it could be a step in that direction. A design space to try out emerging ideas was created by exploring the different ways textiles can be combined with technology, either on material, production, or use level.

OVERVIEW OF PROJECTS

2.1 Digital Stories on Textile	2.1.1 QR-coded Embroidery	2.1.1.1 Story of a Textile
		2.1.1.2 QR-coded Traditions
		2.1.1.3 Local Wisdoms
	2.1.2 Bedtime Stories	2.1.2.1 Little Red Riding Hood
		2.1.2.2 Smart Phocus
		2.1.2.3 Demo Textile
	2.1.3 Textales	2.1.3.1 Dream Bear edition
		2.1.3.2 Sunny Sunday edition
		2.1.3.3 Little Red Riding Hood
2.2 Body Sensing and Actuating Networks	2.2.1 Felt ball	
	2.2.2 Tender	
	2.2.3 Vibration Therapy	2.2.3.1 Vibe-ing
		2.2.3.2 Well-Be
2.3 Thermocraft	2.3.1 CHACUN(E)	
	2.3.2 YB-ML	
	2.3.3 Butterfly Lace	

Figure 5 Overview of the projects in The Portfolio.

Prototypes play an important role in the R&D process, as the carriers of knowledge. The Creative Industries Scientific Program (CRISP) looking into product service systems, and the Smart Textile Services project focusing on the specifics of smart textile services, together serve as a program, as described by Binder and Redtsröm (2006), and carrier for the research. Three smart textile services directions that emerged from working with the material, with three sub-projects (Figure 5) each introduce the smart textile services context. They were a basis for the first person reflections into the process. The projects serve as examples for the evaluations of sustainability and craft qualities in smart textile services. The Portfolio exemplifies three directions for smart textile services with their different levels of integration of textile and technology, intended stakeholders and the envisioned place of use.

The three umbrella projects, Digital Stories on Textile, Body Sensing and Actuating Networks, and Thermocraft, provide a set of examples for smart textile services. Digital Stories on Textile explores the ideas of connecting digital information to textile material. It has three iterations: QR-coded Embroidery (exemplified through Story of a Textile, QR-coded Traditions and Local Wisdoms), Bedtime Stories (exemplified through Little Red Riding Hood, Smart Phocus and Demo Textile) and Textales (exemplified through Dream Bear, Sunny Sunday and Little Red Riding Hood editions). Throughout the iterations, the connection between the textile and its digital contents gets more refined in concept and in technology. Body Sensing and Actuating Networks explores the possibilities to integrate electronic components into textile structures for sensing the body and reacting to it. It has three iterations: Felt Ball, Tender, Vibration therapy (exemplified through Vibe-ing and Well-be). Throughout the iterations, the visual actuation (light) gets transformed into tactile experience (vibration). Thermocraft explores the opportunities for crafting thermo-sensitive materials for performance costumes. It has three iterations: CHACUN(E), YB-ML and Butterfly Lace. Throughout the design iterations, the material adapts more input possibilities, from body heat to electricity and touch. It also enriches the output variety, from one colour change to several different colours in one yarn. All the projects mature in their production-readiness, moving from one iteration to the next one. All three are handcrafted pieces in the first iteration and machine producible objects in the third one.

Each group of projects is described first generally with the motivation that inspired me to work with that specific direction. Detailed descriptions about each subproject follow stating my motivation and intentions that I hoped to achieve with that project, involved collaboration partners, functionality, looks, and intended users. There are projects at three different levels of integration of textiles and technology in the current work. The levels are explained, and put into the context of three main categories of projects. At the end of each project, there is a brief list of production materials, methods and tools used during the process. At the end of the description of each project, the intended services are described briefly and the communication section demonstrates how I have introduced the content of the project to the community and to society through presentations, exhibitions and publications.

The motivation gives an idea of the starting point of the specific project direction. For example, Digital Stories on Textile starts from a cultural background, while Body Sensing and Actuating Networks departs from a material exploration source. Thermocraft starts from a personal curiosity and a wish to slow down time. Intention makes it more specific, explaining what I was aiming to achieve with the specific project. Whether the goals were personal or aiming towards a producible end result also determined the selection of collaboration partners. The people involved in all the projects are mentioned to show the types of competences present in each iteration as well as to give credit for their great work.

Functionality of each project is described to give an idea of how the smart textile proposal works, what it does and what it potentially could do. The looks of the prototypes are described more from the reasoning point of view. The origin of colours or shapes are pointed out if they carry a design story in them. Intended users are mentioned for imagining the prototype in use as a product. It becomes clear where, by whom and how the proposed smart textile service would be used.

Mentioning the production materials, methods and tools makes the role of textile and technology materials and techniques in the project explicit. It is possible to follow the changes from one iteration to other as well as to gain ideas about the making process itself.

The communication part demonstrates how the prototype and the project in general has been brought to the community and to society. It creates an understanding of how the community of researchers, designers and experts around has influenced the course of the project.

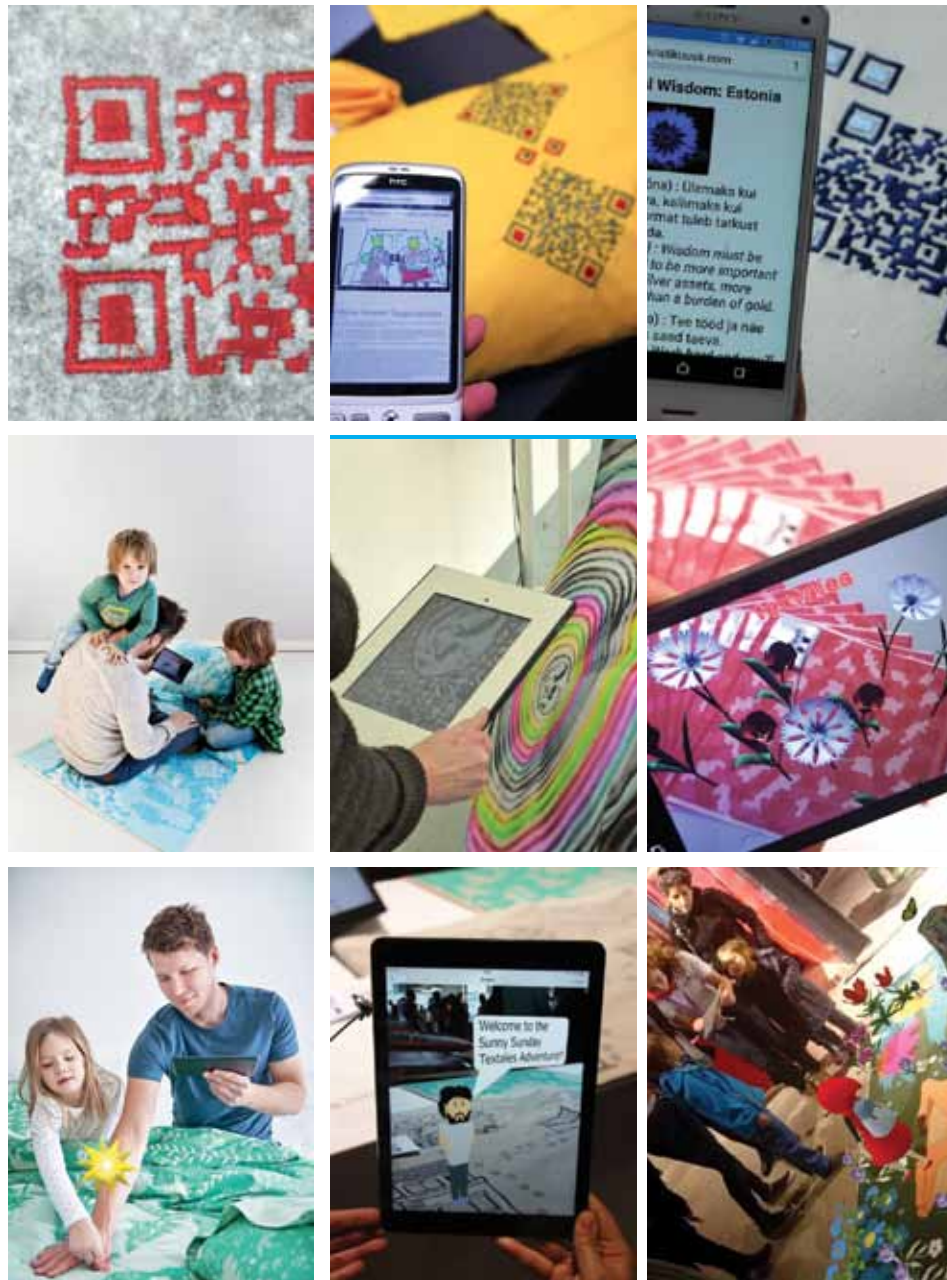


Figure 6 First row: QR-coded Embroidery sub-projects: Story of a Textile, QR-coded Traditions and Local Wisdoms. Second row: Bedtime Stories sub-projects: Little Red Riding Hood, Smart Phocus and the Demo Textile. Third row: Textales sub-projects: Textales Dream Bear edition, Textales Sunny Sunday edition and Textales Little Red Riding Hood edition.

2.1 Digital Stories on Textile	2.1.1 QR-coded Embroidery	2.1.1.1 Story of a Textile
		2.1.1.2 QR-coded Traditions
		2.1.1.3 Local Wisdoms
	2.1.2 Bedtime Stories	2.1.2.1 Little Red Riding Hood
		2.1.2.2 Smart Phocus
		2.1.2.3 Demo Textile
	2.1.3 Textales	2.1.3.1 Dream Bear edition
		2.1.3.2 Sunny Sunday edition
		2.1.3.3 Little Red Riding Hood

DIGITAL STORIES ON TEXTILE 2.1

The Digital Stories on Textile set of projects (Figure 6) explores the interaction possibilities arising from the combination of static textile and digital information in different form(at)s, e.g., image, video, text, audio, 3D object, animated 3D object. My aim was to make textiles last longer and to be more interesting for people using them by allowing the textiles to change in time. Digital Stories on Textile has three main project lines: 1. QR-coded Embroidery, consisting of examples such as Story of a Textile, QR-coded Traditions, and Local Wisdoms; 2. Bedtime Stories, consisting of examples such as Little Red Riding Hood, Smart Phocus, and the Demo Textile; 3. Textales, consisting of examples such as Textales Dream Bear edition, Textales Sunny Sunday edition, and Textales Little Red Riding Hood edition.

QR-coded Embroidery

Bedtime Stories

Textales

Craft values that appear in different forms and patterns throughout the three iterations motivated the project. The set of examples is realized inspired by the way meaning and information was embedded in traditional craft items, such as folk clothing. They value the quality of the material, community and family connections. I set out to find ways to embed sustainable, slow and balancing ideas into smart textile services. Craft and folk items inspired the ways to connect different layers of information through the interaction of textiles and technology. People who belong to the certain community can read the meaning of a pattern on a folk mitten. Similarly, information behind a QR-code or an image marker on a textile can be read only through a smartphone or a tablet interface. In both cases, there is always more in the object than is visible at first glance.

QR-coded Embroidery focuses on folk-inspired QR-codes that are embroidered onto textile items to link the user through the symbol to culturally valuable information in video, image, audio, or text format. Bedtime Stories combines pre-defined images on textile items with the Augmented Reality application displaying static 3D objects on a tablet or a smartphone screen. Textales combines textile images with Augmented Reality and animated 3D objects with sounds. Additionally, it opens up the possibility of being industrially produced, as well as the idea of the development of different stories.

Home

With the digital layer connected to (traditional) textile cloth, our project team explores the possibility of allowing the textile to change in time, as the user and culture do. The software application can be programmed to react to certain inputs coming from the time, space, date, time, wearer, etc. Today, with widely available hardware, we can see the altered reality through the screen of a smartphone or a tablet computer. In the near future such features can be expected

to be accessible to the general public in devices such as Google Glass (Allsopp, 2015), Microsoft HoloLens (Microsoft, 2015), BMW Mini goggles (Esqueda, 2015), contact lenses (Statt, 2014) or other products yet to appear.

Digital Stories on Textile projects are used either at home or outdoors, in a circle of family and friends. Its main user is a family member who likes to create and share meaningful stories. The creation of stories, illustrations, characters and other digital content suggests a service approach rather than product-based marketing model. Also the platform creator and administrator, textile producer and care professional (textile cleaning, software assistance) become potential service providers in the scenario.

Levels of integration of textiles and technology in Digital stories on Textile

Digital stories on Textile falls into the generation of smart textiles that Andreas Köhler (2013b) calls adoption, and refers to textiles as a platform for embedded electronic devices, such as pockets. Koen van Os (2013) from Philips Research recognises this level as First, under which he places the project with weaving data lines. He cites the Georgia Tech Wearable Motherboard (Jayaraman & Park, 1998) as an example of this category; that is a textile with woven conductive threads that connects to monitoring devices to observe the vital signs of humans in an unobtrusive manner.

The textile and smart phone or tablet device are independent functioning items in the Digital stories on Textile examples. The textile items can be used as pillows, duvet covers, picnic sheets, etc. and the smart phone or tablet device continues working normally regardless of the added functionalities that they both acquire in the Digital Stories on Textile concept. They are completely separated in the physical material level and brought together by the fairy-tale application to perform an additional functionality that extends the functions of both.

Separated



Figure 7 QR-coded Traditions. Photo creative production: PR fashion room. Photography: Arttu Karvonen. Model: Kertu. Kertu's Dress: MARI. Kertu's accessories: New Vintage by Kriss.

The idea to place digitally recognizable information on textiles came from the visual parallel between a black and white mitten pattern and a QR-code (Figure 8). Mittens in pre-industrial Estonia did not only keep people warm. They were believed to have protective functions. That's why they were worn even during summer when dealing with important matters (Puppert, 2011). Conceptually both the QR-code and a pattern on a mitten carry different layers of information. Today most of the symbols, colours and materials used in the mittens are unknown to the people living in the community. Since the meanings in traditional crafts are getting further from people's daily lives, I wanted to embed the information in the textile in a contemporary way via technology. The dynamic layer of digital technology seemed to play a significant role in moving smart textiles towards a more sustainable direction. A QR-code can reveal a lot of information, similar to a traditional garment, accessory or ornament, which could carry magic powers, personal information or traces from the community. Both a folk garment and a QR-code need a key to access that hidden level of information. In traditional crafts, the introduction

to community knowledge is required to understand culturally embedded meanings. To access the content of a QR-code smartphone with a QR-code, reader software is needed.



Figure 8 Left: folk mittens as visual and conceptual inspiration for embedding information to textiles through QR-codes. Right: a QR-code giving the link to the example Story of a Textile.

The QR-code on top of a textile item connects the user to its digital content. The user can scan the code with any QR-code reading software, for example, “I-nigma QR & Barcode Scanner” (GVision, 2013). The recognition of the QR-code will direct the user to a linked website. Even though the embroidery on the textile should change as little as possible in time, the digital content could be updated continuously. The site can be updated by different stakeholders, programmed to provide automatic content or be responsive to user input.

Estonian folk costume colours inspired the QR-coded Embroidery sub-projects. They draw a parallel between the location the colours originate from and the content the QR-code is referring to. For example, in the case of scanning a bag from the Local Wisdoms series, which is made in Northern Estonian colours, the quotes, poems and sayings that would appear would be from the writers from that region.

QR-coded Embroidery groups together a set of prototypes that have QR-codes embroidered on textiles to relate the static durable textile to the dynamic changeable digital world. While a traditional quality-aimed technique, such as embroidery, is long lasting and pleasant to touch, the digital layer connected to it provides an opportunity for the textile product to act in a service system to stay updated and change content throughout time. The first QR-coded embroidery prototype is a textile telling the story of the material’s whole life cycle – The Story of a Textile. The second prototype is a pillow showing fairy-tales – QR-coded Traditions. And the third one is a daily item sharing built-up knowledge of a specific community – Local Wisdoms.

Collaboration partners

The projects in the QR-coded Embroidery section are developed as individual prototypes, which I conceptualised, machine embroidered and sewed. The connection between the digital and the physical, the QR-code and the sample website was executed by myself.

Motivation

Story of a Textile (Figure 9) is a way to attach the information embedded in the materials lifecycle to the actual cloth to be more conscious about the material impacts of creating the specific product. Usually, the fabric rolls come into a production factory with labels about their origin. The textile producers know from where they ordered the yarns. The thread spinners must know the origin of the raw material itself. However, all this information gets lost on the way to the end user. Therefore, Story of a Textile aims to provide the user with visual and written information about the material their items are made of. The idea builds on traditional pre-industrial crafts, when the craftsmen knew the material journey primarily because everything was local. With industrial production, where specialized factories are distributed all around the world, tracing the material origins becomes difficult. The production chain is not very transparent and therefore a lot of essential information about materials, production methods, chemicals used and the distances the cloth has travelled gets lost. Sometimes the information is not very pleasing, and it becomes easier to hide it than to explain it to the users.

Functionality & Looks

When scanning the QR-code embroidered on the cloth or a garment, a website opens with information about the raw material and chemicals used for making the textile. The spinners, weavers, knitters, dyers, printers, cutters, sewers and everybody else involved in the production chain can leave their mark. The recording of the material’s life would not stop with the end user. They could also upload their information so that the item would have a living documented history. If it gets sold to another person through a second-hand market, the story of the journey of the textile would continue.

The QR-code needs to fit the garment. Each item should have its personalised code, which could be adapted at each exchange point. For example, when a fabric is cut and sewn into several garments, the code needs to change, keeping the history, but allowing each item to develop its individual future. The same would happen when one garment becomes several new ones. The Story of a Textile shows the passage the material has experienced as told by the people who have been part of that journey.



Figure 9 Left: an example of an embroidery telling a story of a textile. Right: the screenshot showing the journey the textile has gone through.

Meaning

With the Story of a Textile I found out how to embroider QR-codes on different materials. I made the idea of connecting physical static textile code to digital changeable website tangible. It touched the topic of my concern: garment sustainability. However, it did not speak to a wider audience since it is difficult to connect to the specifics of clothing production. I realized that I need to create a design example that people can identify with more easily in order to create a bridge for communicating the textile sustainability issues to the general public. The following two iterations are about fairy tales and local wisdom connected to everyday items, such as pillows, groceries bags, etc., that are closer to more people than the ideas of tracing textile history.

Motivation

With QR-coded Traditions, I intended to connect cultural traditions and history through several layers, while encouraging new ways of interaction. The bright yellow pillow carrying an embroidered QR-code gives information in a hidden way, just like the traditional folk skirt it is inspired by. Seeing the traditional folk skirt from Estonia – Muhu skirt – people who do not belong to the community could guess that the rich system of colours and patterns must tell a story about the wearer and the community she belongs to. For example a lady wearing a “tanu” (a type of hat) is definitely married. To get to know the exact message the skirt carries, they would need to get access to the community’s knowledge. Similarly, seeing the QR-code embroidered on a pillow, people could recognise that it’s a QR-code. However, to understand what it says, they’d need to scan it with a QR-code reader on their smartphone. The textile is connected to the digital technology through the visual inspiration meaning they both carry. They have a related story to tell. The pillow is communicating through its colours and shapes while the website stores stories in digital formats.

Functionality & Looks

When scanning the QR-code embroidered on the pillow, a fairy tale shows up. The story originates from the same location as the folk garment used as inspiration. The fairy tale can appear in any digital format. In the example, a cartoon and text of a fairy tale show up. There can be several pillows with same code showing the same story. However, the pillows can also have different codes, and different digital content connected to it. The appearing story could be customized for a specific person, period or time of a day by providing specific input for the system generating the content. There is a strong link between the vivid colours used in the Muhu skirt, used as inspiration for the project, and the pillow itself. The colours indicate where the story that is revealed by technology comes from. Each region could design its QR-coded Traditions and share its culture and stories through it.



Figure 10 Left: Muhu folk skirt, as the inspiration for QR-coded Traditions pillow. Skirt photo: EVM E 304:1, Eesti Vabaõhumuuseum SA, <http://muis.ee/museaalview/981738>. Right: QR-coded Traditions pillow.



Figure 11 Left: QR-coded Traditions as a pillow inspired by Muhu skirt, telling Estonian fairy tales. Right: the screenshot of the website with the fairy tales.

Meaning

With QR-coded Traditions I expanded the motivation of embroidering QR-codes to textiles by discovering different layers of meanings they could connect. I realised the strength of relating the digital realm to traditional and folk inspiration. The idea was intuitive and received a lot of interest from people. For example, it was appreciated that a local pattern could carry a local fairy tale. The very first comment about this idea came from a Dutch woman who expressed her enthusiasm about how she would like to send such a pillow with Dutch fairy tales to her sister's family who had just moved to Australia. It had created the bridge to talk about textile sustainability through smart textile examples. To broaden the application area from pillows and fairy tales to different objects and contexts, I developed the next iteration, Local Wisdoms, displaying proverbs on grocery bags.

Motivation

With the Local Wisdoms (Figure 12, Figure 13) series of items, I connect the community's stored valuable information to a younger generation through technology, similarly to the way knowledge used to be passed on while crafting together. As in Story of a Textile and QR-coded Traditions, the aim was to allow the textile material to live longer by allowing it to carry information that could change and grow in time. The wisdom of poets, writers, philosophers, elderly neighbours, etc., would be passed on to the children from the community. Such a garment would become a link to an always-growing database, making it more and more valuable in time.

Functionality & Looks

Scanning the embroidered QR-code on a grocery bag or a home textile would reveal sayings, proverbs, and poems written and said by the local community. For example, a pattern originating from Estonia could reveal poems by local poet Juhan Liiv. As an example, the pattern inspired by Kuusalu folk garments (Figure 8) reveals Estonian proverbs. The wisdom database could be always growing. Users could see new proverbs or sayings every day. They would be always connected to the area that the design of the item is inspired by. A Local Wisdoms grocery bag or a home textile has the embroidery of a QR-code inspired by the traditional patterns of a specific region. The QR-codes links the user to sayings, proverbs, and poems by people from the same area the design of the code comes from.

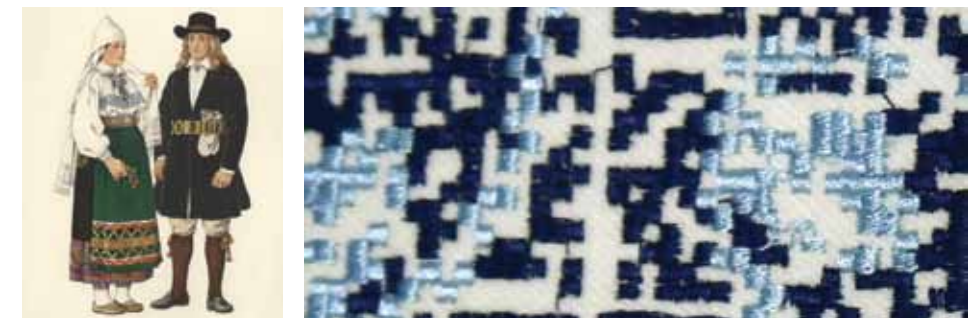


Figure 12 Left: Kuusalu county and North Estonia folk clothing (left) that inspired the Local Wisdoms bag QR-code design (right). Drawing by Melanie Kaarma. Eesti Rahva Muuseum ERM EJ 415:12. Right: detail from the Local Wisdoms embroidery.

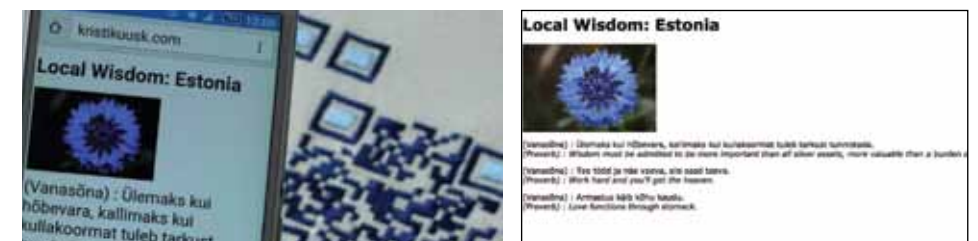


Figure 13 Left: Local Wisdoms groceries bag quoting Estonian proverbs. Right: the screenshot from the website the QR-code refers to.

Video <https://vimeo.com/151435124>

Meaning

With Local Wisdoms I could experiment with the complexity of the patterns of the QR-code. I tried to stylise them inspired by the Estonian folk embroidery. I experimented with the balance between the aesthetic embroidery I desired to achieve and a functioning QR-code. The iteration also strengthened the ideas about how dynamic and adaptable the digital layer could be, and how users could add their information and content to it. In the next iteration, Bedtime Stories, I start to experiment with a more flexible digital world in collaboration with industry partners.

QR-coded Embroidery intended users

Users

End-users benefit from the items which belong under the umbrella of QR-coded Embroidery. The garments marked with the QR-code from the Story of a Textile series are worn by people at work, home, streets, etc. A QR-coded Traditions fairy tale telling pillow could also decorate and bring interactivity to homes or offices or even be brought along on trips and outings. The Local Wisdoms bags are suitable for daily grocery shopping. The exploration phase started by seeing the end user as a receiver, who gets an item decorated with the code and moved towards giving an active role to the user. Users can add photos and information about their personal experience with the garment or accessory carrying the Story of a Textile. The fairy tales attached to the QR-coded Traditions can be chosen or even read into the application by the users themselves. And Local Wisdoms items, besides carrying the embedded wisdoms, could allow people to add location-based information to the digital database.

QR-coded Embroidery envisioned service

Service

The digital connection with the traditional textile brings along an opportunity for services to emerge. All the digital data used in the projects needs to get updated. There are opportunities for service providers to create the desired content: research about materials and their traces, finding and connecting different fairy tales, creating new versions of existing stories, and collecting wisdom and cultural information from local communities. Service can support the use and creation of digital content as well as the creation and maintenance of the textile items.

Story of a Textile carries information about a mutual journey of many actors. It stores for example the traces of people growing and treating the raw material, the notes from the textile production facility, the comments from the garment manufacturers, and finally the impressions of the people wearing the items. Each person playing a role in the garment's life cycle is a potential stakeholder in the envisioned service. They all would receive support to upload the information in a rewarding way. They, in return, could use the information from other parts of the journey to know more about their items: where it goes to, or where it comes from. Such an overview could give insights for strategic planning for government.

QR-coded Traditions connects people through their digital devices to traditional fairy tales. The service connects the end user to the story creator, who connects the end user to the tradition of a specific location. Offered service can support the creation of the fairy tales, design of the QR-codes as well as the production and maintenance of the pillows.

Local Wisdoms brings knowledge embedded in the culture of local people into view. It shows forgotten or otherwise less known phrases, poems, know-how, and sayings from elders or already deceased generations to the youth through technology. The service connects the traditional values to the location of their origin through a QR-code. The envisioned service allows the phrases to be collected and submitted to a central database and accessed via the mobile phones.

Production of the QR-coded Embroidery materials, methods, tools

When developing the first iteration of Digital Stories on Textile I started out by working with materials that I could work with by myself. I machine embroidered the generated QR-codes on different woven fabrics. The websites showing the textile journey, the fairy tales and the local wisdoms were made with simple HTML codes and designed to be fast and robust. They had to communicate the idea, but remain unfinished enough to open up a conversation about which direction to take the project next. Cut & sew methods with overlock and industrial sewing machine were used to prepare the examples, such as the pillow and the grocery bags.

Materials,
methods,
tools

QR-coded Embroidery related communication to the community & society

The projects carrying QR-codes inspired by Estonian folk costumes were shown to the community of researchers, designers and industry partners in various presentations and academic publications over time. As a starting point of the Digital Stories on Textile project, they were analyzed from the craft qualities perspective in The Nordic Textile Journal in 2012, and conference papers presented at NORDES2013 and Art of Research V 2014.

Community
& society

The first opportunity to show the QR-coded Embroidery outside the immediate community was during the Hypercrafting Fashion event in the Waag Society in January 2012 in Amsterdam. The event was memorable because of the very enthusiastic first reaction I received for the work from a community of craft-minded people. They asked different types of questions and appreciated aspects, such as storytelling, that were not in focus for the academic audience. The main benefit of showing the early progress of work outside of a safe environment was to understand what people liked and what kind of prototypes were more likely to engage them in a conversation. Also the first newspaper and web articles that gave a clue of how my work was seen outside of the university were about that event. Exhibitions and presentations in Belgium, the Netherlands and Estonia followed.

1.1 BEDTIME STORIES



Figure 14 Bedtime Stories Little Red Riding Hood. Photography: Hanneke Wetzter & Bas Berends (Studio HUID & HAAR). Models: Stephan, Sem, Reeve.

Bedtime Stories is a second iteration of Digital Stories on Textile, following QR-coded Embroidery. With this iteration, the individual expression of cultural background changes to team motivation. Also, my individual skill and tool set changes to that of the collaboration partners. I bring the craft values in the context of sustainability and inspiration to the industry partners. They add their expertise in weaving and software development areas. The aim is to take a step towards producibility and to scale up. The connection between the static durable textile products and the ever-changing digital application allows the content or even the purpose of the application to change in time while keeping the same cloth.

When a woven or printed symbol (for example a flower, a forest or the house of the grandmother in the setting of the Little Red Riding Hood fairytale) on the fabric is scanned and recognised by the Augmented Reality software on the tablet device held by the storyteller, the user can play with the textile to manipulate the digital 3D visuals. The action of activating visuals on the screen based on physical touch of the textile creates interaction possibilities between digital and physical worlds. They merge through the meaning that is created by the interaction that the user has with the textile.

Bedtime Stories projects allow visual surprise to occur. The textiles tell a story already with the cloth. The extra layer of 3D information that the tablet application reveals adds magic to the initial one. It grows flowers where they have been already “planted” in the duvet cloth.

Bedtime Stories groups together three example projects, where textile is coupled with technology through an Augmented Reality application. In Little Red Riding Hood and Demo Textile the recognisable images are woven into fabrics. The grandmother pops up when the tablet application is used near the house symbol on the cloth. In Smart Phocus the envisioned artwork is printed to a knitted stretch fabric instead. The Augmented Reality software application makes visual noise appear on top of a colourful fabric.

2.1.2.1 LITTLE RED RIDING HOOD

Collaboration partners

Little Red Riding Hood was developed in collaboration with Unit040, Johan van den Acker Textielfabriek and Studio Toer. Unit040 is a software company based in Eindhoven, which is focused on making high-tech industry products generally accessible by developing 3D models (Unit040, 2015). Johan van den Acker Textielfabriek has woven high quality textiles since 1807 (Johan van den Acker Textielfabriek B.V., 2015). Studio Toer is a collaborator of Unit040, which explores the boundaries of product and spatial design (Studio Toer, 2014).

My QR-coded Embroidery prototypes brought the team together and my role was to allow the project to develop towards the interests of each partner. As one of the collaborators, I conceptualised the frame for the project, discussed with each party to understand how they would like to contribute to the project, reflected on the prototype in the research process, and led the project of developing the next design. I visited each partner occasionally, arranged meetings and made sure everything was delivered as agreed. I cut and sewed the prototypes and arranged their appearances in exhibitions and presentations. Unit040 developed the software for the Little Red Riding Hood application. Studio Toer contributed with their interaction design, graphic design and 3D modeling skills. Johan van den Acker Textielfabriek wove the textile.

Motivation

In Bedtime Stories Little Red Riding Hood (Figure 11), we explore the ways to weave traditions together with technology. The concept connects traditional values and crafts with digital technologies for sustainability. It offers an alternative way to translate fairy-tale knowledge into people's personal experiences and pass that wisdom through generations as well as building up family stories together. Bedtime Stories Little Red Riding Hood allows the user to put the child into the story creation to experience the fairy tale. A linear way of reading from a book is replaced by customised experiences, enriched by values and meanings added by the storyteller. The parent can create his story using inspiration from the fairy tale but adding his own elements, characters and experiences to it in a digital or physical layer. Personal values get transferred together with the cultural meanings and the product very exquisitely becomes part of a combination of product design with service elements to contribute to a more sustainable smart textiles field.

Functionality & Looks

Bedtime Stories Little Red Riding Hood is a combined product consisting of a duvet cover, pillowcase, specially developed augmented reality fairy tale application and an iPad to use the application. The appearing magical 3D characters allow parents to create personal stories with their kids while going to sleep or at play time. The technology makes use of image recognition algorithms, which make it possible to recognise certain patterns and pictures in the textile. When moving over the pattern with the iPad, it recognises and connects to certain objects in the story that are visualised in an augmented layer. The interaction creates a conversation between the digital and physical worlds. When a woven symbol (for example a flower, a wolf or a grandmother in the setting of the Little Red Riding Hood fairy tale) on the fabric is scanned and recognised by the tablet computer held by the storyteller, the child can play with the textile to manipulate the digital visual. Customized experiences replace a linear way of reading from a book. The parent can create his story using inspiration from the fairy tale but adding his elements, characters and experiences to it in a digital or physical layer.

The bed linen is made of a durable textile that is woven in The Netherlands by Johan van den

Acker Textielfabriek. The story that covers the duvet cover and pillows is designed by Studio Toer. It represents a generic forest with a lake and a house that is able to accommodate other stories in the forest setting. The 3D characters appearing on the textile once visual markers are recognised by the tablet camera and are designed by the same company. The application bringing the image recognition on textile together with the Augmented Reality characters is developed based on Vuforia (Qualcomm, 2014) by Unit040.



Figure 15 Bedtime Stories Little Red Riding Hood. Photography: Studio Toer. Models: Christine, Lise.

Video Video introducing the Bedtime Stories Little Red Riding Hood: <https://vimeo.com/82085368>

Meaning

With Bedtime Stories I saw how Augmented Reality literally becomes an added layer for a textile. Compared to the previous QR-code experiments, this medium gave much more freedom to create attractive content, and the information in the form of fairy tale characters could be displayed directly on the textile. Being able to work with industrial machines and larger surfaces gave an idea of the producibility potential for the concept. Collaboration with a software company opened up possibilities for creating more attractive digital content and therefore reaching even more people curious about the concept. For example, I was approached by a museum in Breda with an invitation to collaborate with artist Sabine Staartjes, who was going to create an exhibition installation piece there. This project, Smart Phocus will be explained next.

2.1.2.2 SMART PHOCUS

Collaboration partners

Smart Phocus is developed in collaboration with Unit040 and Sabine Staartjes. Staartjes likes to design contrasts and contradictions. She focuses on making experimental collections suitable for exhibitions and fashion shows (Staartjes, 2015).

The Bedtime Stories Little Red Riding Hood project brought the team together. On one hand the Smart Phocus project showed how the concept can benefit from including people external to the development process. On the other hand it clarified my role as a bridge between the artist and the technology. Again, I was explaining and “translating” between the two worlds leading the project further on. Unit040 was developing and improving the Augmented Reality software application and Staartjes was developing the artistic concept and graphic design for the textile and the Augmented Reality layer.

Motivation

I was eager to apply the technology and knowledge developed within the Bedtime Stories Little Red Riding Hood project into the artwork called Smart Phocus (Figure 12) by Sabine Staartjes (2015). When the Museum of Image (MOTI) in Breda, The Netherlands, approached me to initiate the collaboration, it seemed like an excellent opportunity to see what other designers would like to do with such combinations of textiles and Augmented Reality. The project was shown in the “Te[ch]x(t)iles” exhibition, where selected artists were asked to show their vision on the future of fashion. It was a way to allow the project to develop outside of the surrounding community in the larger society. Staartjes’s art piece expresses concern about the amount of technical noise around people and stresses the importance of focusing on each other.

Functionality & Looks

The eyes, ears and lips that are part of the textile design are recognised by the camera in the tablet device and an augmented layer of “noise” and information is displayed on the objects. The software application developed for Bedtime Stories Little Red Riding Hood was adapted to demonstrate Sabine’s idea about the future of fashion. Sabine’s installation consisted of two colourful coats with different parts of the body printed on them. The ears and eyes were central image recognition points for the tablet application. With the artwork, Staartjes reflects on the importance of the smartphones in people’s lives. She asks whether talking through a smartphone is still communication.



Figure 16 Smart Phocus, the art project of Sabine Staartjes.

Video Documentary video about the making of the project: <https://vimeo.com/63710148>

Meaning

Smart Phocus was the first attempt to include people outside of the CRISP project in the creative process of Bedtime Stories. For me, it clarified my role and value in the project as a translator between the worlds of textile art/design and technology. From a material point of view, it was nice to try out how the image recognition would behave with an elastic textile. It does hold interesting possibilities for interaction between the physical and digital worlds. I also saw that our way of working and technology didn’t allow the artist to form her ideas freely. The creation process was limited by what we had provided as an example for the use of the technology. I acted as a translator between the artist’s vision and the technological limitations of what the team was able to implement in the provided time and budget. Therefore, as a next step with the collaboration partners, we created a Demo Textile to allow interested people to play and experiment with a more open and neutral example of cloth. The new example can be seen more as a piece of textile, and less as a finished product carrying a fairy tale experience allowing the people interested in the combination of textiles and Augmented Reality to try out and form their ideas around the concept.

*A translator
between the
worlds of
textile art/
design and
technology*

2.1.2.3 DEMO TEXTILE

Collaboration partners

Demo Textile is developed in collaboration with Unit040, Johan van den Acker Textielabriek and Studio Toer. The team had the same responsibilities as when developing Bedtime Stories Little Red Riding Hood.

Motivation

Bedtime Stories Demo Textile (Figure 13) was developed to open up the concept of Bedtime Stories to wider application areas. While fairy tales and kids led to a very interesting direction, the project team aimed to allow people to think along and to imagine the combination of Augmented Reality on textiles in their context for their use, and not to be limited by the initial fairy tale setting. It is common to use swatches as smaller textile samples in textile industry to give an idea of the proposed product line to the prospective clients. Similarly, software companies offer demo versions of their applications to communicate and to give an understanding of the experience their specific software offers. To be able to communicate to both fields, the project team decided to create a small piece of textile with an application communicating the essence of the project in a context neutral way. Therefore the chosen theme was a textile field with digitally growing flowers.

Functionality & Looks

Demo Textile cloth can be used on a surface, but also on a body or wrapped around different objects, etc. Demo Textile is an open-use cloth, therefore different ideas and concepts can be explored with it. When scanned with the software application on a tablet or smartphone device, the digital flowers appear on top of the red canvas. The flowers can be manipulated by touching the textile. When developing the Demo Textile, the team put considerable effort into fine-tuning the textile pattern to achieve a result where the designers were happy with the aesthetics and the image recognition Augmented Reality application would result in a stable 3D projection of flowers on the textile surface. Getting to know the basics of image recognition software over several design iterations helped the graphic designer to propose a very stable end design – when the cloth was moved, the flowers moved along much more smoothly and more reliably than in previous versions.

Demo Textile is a woven cloth with digital flowers growing from it. The red surface resembles the Brabants bont – the textile pattern originating from Brabant area, where Eindhoven, the home town of the project, is situated. The flowers represent cultures of the project partners involved at the moment of developing the concept. Three tulips stand for the Dutch and one cornflower for the Estonian involved in the project.

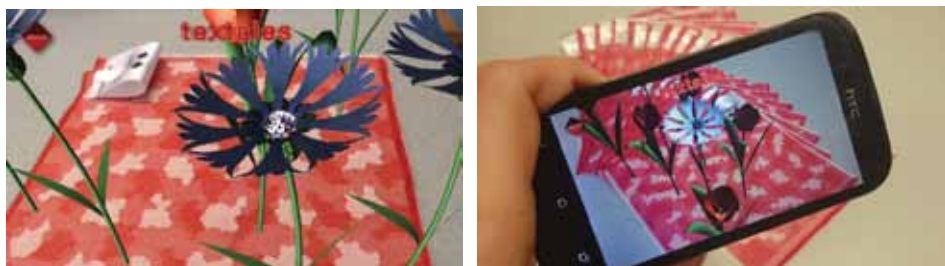


Figure 17 Demo Textile. The application is available for Android device in Google Play (Textales Demo edition).

Meaning

With Demo Textile, the concept of using Augmented Reality on textiles was opened up. It could be used as an interior textile, garment or anything that is made of textile. We envisioned people thinking along and discovering applications they would like to use. We also created a Kickstarter campaign (to be explained in Chapter 6) with Bedtime Stories. That experience taught us that it is beneficial to keep concepts open when working with artists or designers; however, an end user likes to have a specific product telling a very concrete story. With that insight, along with the first version of craft qualities (Chapter 4) and sustainability qualities (Chapter 5) in mind, I started to arrange the development of the next iteration of Digital Stories on Textile – Textales Dream Bear edition, where I involved a local storyteller to share her vision of a modern fairy tale told through a textile.

Bedtime Stories intended users

End users benefit from the items which belong under the umbrella of Bedtime Stories. The Little Red Riding Hood bedcover can be used at home or anywhere a family goes. Smart Phocus can inspire people at exhibitions. Demo Textile can be used by curious people who are interested in the specific combination of textiles and Augmented Reality. They can play around with the cloth and the digital flowers planted in it to find new directions that can be developed. While the first iteration of the Little Red Riding Hood focuses the project to a specific context and makes it easy to communicate to end users, the other two open it up for exploring other directions and meaningful uses for the technology. The Smart Phocus project is an attempt to allow the artist to model the concept to her vision. Demo Textile offers an opportunity for more people to try out and brainstorm how the concept could be applied in different fields. The sample cloth has been given to interested people to try out the application.

Users

Bedtime Stories envisioned services

The concept allows three different levels of services to appear. Firstly, the end users can be provided with pre-made content as stories, art pieces or materials they could work with. Little Red Riding Hood projects elements of a well-known story to the textile canvas. The families can play with those characters when telling the fairy tale to their children. With Smart Phocus, Staartjes created an art concept that was communicated to museum visitors in different parts of the world. Demo Textile was created as an open material people could brainstorm and experiment with. It can be made into different shapes and items.

Services

Secondly, the service allows the professional storytellers, artists and material designers to create such stories, art pieces and materials. That service was custom made in the described phase of the project. However, standardising and automating some steps would bring the project closer to the next option.

Thirdly, the service model could support the end users themselves to create the stories, creative works and new materials. To achieve that with a cost accessible for a typical user, some parts of the process would need to be simplified, unified and eventually automated.

Bedtime Stories production materials, methods, tools

During the second iteration of the Digital Stories on Textile project, the project team grew to include a textile producer making woven fabrics, a spatial design company and a software development company. Therefore, the embroidery technique was changed to weaving beautiful patterns straight into the cotton textile. Instead of quick demo websites, the technical partners created 3D characters and an application to view them through Augmented Reality. For the Smart Phocus project, knitted textile with a print was made instead, as the collaboration partners

Materials,
methods,
tools

of Staartjes produced it. Cut and sew techniques with overlock and industrial sewing machines were used to create duvet covers, pillows and swatches.

Bedtime Stories related communication to the community & society

Community
& society

The projects combining textiles and Augmented Reality through the image recognition application were shown to the community of researchers, designers and industry partners in various presentations and academic publications over time. As a second step in the Digital Stories on Textile project, they were analyzed from the craft qualities perspective in *The Nordic Textile Journal* in 2012, and conference papers presented at NORDES2013 and Art of Research V 2014, ISWC 2014, DIS 2014. As one example of the smart textile services, Bedtime Stories was analyzed from the sustainability qualities perspective in *Ambience'14&10i3m*. The project was shown in academic exhibitions as part of the E-textiles 2013 Swatchbook at ISWC 2014 and NORDES2013 design research exhibition.

Bedtime Stories was shown during numerous presentations and exhibitions outside of the immediate community, both in the Netherlands and internationally. It was first shown in various locations during the Dutch Design Week in 2012. Bedtime Stories Little Red Riding Hood was part of a travelling ArchInTex network exhibition, shown in Belgium, Latvia, Lithuania and New Zealand. Staartjes's Smart Phocus project also travelled around in the Netherlands and to Israel. I presented the project for smaller and bigger audiences, but the most valuable were the demo sessions, for example during the Nerds on Stage event, where young people could experience the magic of digital stories on soft textile. People asked clarifying questions and gave their personal feedback during those one-on-one interactions, which formed my understanding of the project, and allowed it to become clearer and broaden simultaneously.

A very valuable step within the Bedtime Stories project development was preparing a crowd funding campaign. This will be explained further in Chapter 6. The feedback from potential customers and possible collaboration partners helped to bring the project further with much richer understanding of how society perceives the research project. It helped the project team to re-organize to cover missing competencies and offered insights about what matters to the outside audience and how much they would like to be involved in the product development process. It was interesting to follow the types of news and comments people shared about the project on the web and through social media at that time.



Figure 18 Textales Dream Bear edition. Photography: Katrina Tang Photography, Models: Linda Nete, Airon, Taavi.

Textales is a third iteration of Digital Stories on Textile (2.1), following QR-coded Embroidery (2.1.1) and Bedtime Stories (2.1.2). Here the concept matures and explores two different directions for implementing craft (Chapter 4) and sustainability qualities (Chapter 5) as seen in the first interviews with the craft and sustainability experts. The commercial end user application and a community built alternative will be developed. The motivation for connecting digital dynamic properties with high quality textile is to extend the longevity of textile products through changing the idea of what textiles can do. I apply the knowledge gained from the research into the redesign, and extract further information via and from the new designs Textales Dream Bear, Sunny Sunday and Little Red Riding Hood editions. The project explores further the combination of textile tradition and technological innovation. Digital properties extend the textile capabilities and allow the long-lasting textile to change in time to follow the pace of life of the users. For example, the type of stories told to children can change as they grow older. The developed stories demonstrate the possibilities for such storytelling.

Textales combines traditional textile techniques and the Augmented Reality fairy tale application. Visual markers, in the form of images, on the textiles are recognised by the software application on a tablet or a mobile device. The spotted markers trigger the application to show 3D characters or another type of data in the Augmented Reality layer covering the textile.

The textile surface has image markers hidden as part of the main design. The cloths by themselves are aesthetically pleasing objects to have around the house. The magical layer gets more and more detailed and evolved as the project continues. The static story characters accompanied by subtle sounds in the Textales Dream Bear edition turn into animated figures performing actions on the cloth on the Textales Little Red Riding Hood edition, for example, Little Red Riding Hood picking flowers or the wolf roaring in the grandmother's house.

2.1.3.1 TEXTALES DREAM BEAR EDITION

Collaboration partners

Textales Dream Bear edition (Figure 19, Figure 20) is developed in collaboration with Unit040, Johan van den Acker Textielfabriek and Kerstin Zabransky. Zabransky is a storyteller and illustrator from Eindhoven, whose illustrations gain inspiration from children's stories (Zabransky, 2015).

Johan van den Acker Textielfabriek and I continued with similar roles as described in Bedtime Stories project. Besides the software, Unit040 developed the 3D characters based on Zabransky's illustrations. Zabransky created the Dream Bear story concept, the characters and the design for the textile. Together we chose suitable sounds to accompany the scenes in the story.

Motivation

In Textales Dream Bear edition, I apply the first version of craft qualities and sustainability qualities, which will be explained in chapters 4 and 5. The main motivation is to involve a local storyteller-illustrator, Zabransky, to give a unique content to the story. The hope was to explore the interaction possibilities a professional children's book author would discover. Textales Dream Bear allows the parents to share stories with their kids. The shared tales can be personal experiences subtly woven into the bear narrative, the original Dream Bear adventures or creative imaginations based on the randomly appearing characters of the story.

At first Zabransky proposed to develop a story about a treasure hunt, which would take place in a water setting. The first sketches did not have enough edges and corners to work well with Vuforia image recognition software, and she decided to adapt her idea to design a forest setting. She found it a better fitting scenario for creating an illustration with high contrast, rich detail and without repetitive patterns, as recommended by Qualcomm for Vuforia image targets (Qualcomm, 2015). The forest setting was then fine-tuned over the process of finding the best recognition areas and making sure it fit with the story.

Functionality & Looks

The tablet or smartphone application, accompanying the duvet cover and the pillowcases, adds an extra layer to the tale by revealing magic characters in the fairy tale forest. The robin, owl, rabbits, fish and other 3D characters appear in the augmented reality application with sound effects on the cloth after the textile has been scanned with the application on the tablet or smartphone device. To achieve different types of storytelling experiences, the Textales application has separate settings for the storyline/narrative to be on, off or random mode. In case of the narrative being active, the application recognises only the images that follow the predefined sequence. For example, the owl only appears after the robin has already been spotted on the cloth. This encourages the user to explore the story in a specific order. If the narrative is switched off, the application recognises all the defined images, whichever is first spotted by the camera of the tablet or smartphone. This allows the user to choose which area of the duvet they wish to explore and choose their own storyline. The random narrative option invites the user to spontaneously come up with new explanations for the storyline, as it takes a new order every time.

In the Textales Dream Bear edition, the sleepy bear goes wandering around the forest. Kids can follow the story narrated by their parents and find out how the Dream Bear encounters, among other adventures, a star, fish, rabbits and an owl. The woven textile design is refined to each story element, so that the duvet cover alone can be explored for an interesting adventure. Through the Textales tablet, or mobile application previously mentioned, characters appear and guide the



Figure 19 Textales Dream Bear edition. Photography: Katrina Tang 2015. Models: Linda-Nete, Airon, Taavi.



Figure 20 Textales Dream Bear edition. Photography: Katrina Tang 2015. Models: Linda-Nete, Airon, Taavi.

Video Video introducing Textales Dream Bear edition: <https://vimeo.com/130356417>

Meaning

Involving a local illustrator-storyteller in the project took it to a new level both in terms of the development in textile and digital content design as well as the story development, which

became the center for the project. We could try out new elements, such as the sounds that would follow the characters. For example, the robin started to sing and fire started crackling when they were recognised. We also tried out the possibility of using different modes in the application, to display the story in narrative, random or open mode. The appearance of the duvet and the digital characters became much more attractive for the kids and their parents because of the rich visual details and embedded contextualized animals with tales.

Being developed as a collaborative project among industrial partners, the content became professional and closed to changes. For example, each time the storyteller wished to implement a small change into the story, such as introducing a new character, the implementation to the application would need to be done by the technical partner. That meant the team would need to find time and resources for it. The developed application also did not allow the end users to modify or add their own content. To explore more open and less professional aspects of the combination of Augmented Reality on textiles, I started to create Textales Sunny Sunday with a group of friends.

Collaboration partners

Textales Sunny Sunday edition (Figure 21) was developed in collaboration with Johan van den Acker Textielfabriek, Gordon Jack, Ioana Iliescu-Jack, Dominika Potuzakova and Michal Rouha.

Jack (2015) is an architect with an interest in applying his skills also in other fields. He created most of the initial 3D characters for the project. Iliescu-Jack, also an architect by education, contributed with her graphic design skills, designing the picnic cover for the project. Potuzakova and Rouha added a 3D model of themselves taking a photo in Prague. Johan van den Acker Textielfabriek wove the textile. I developed the initial idea, brought the team together, coordinated the process and sewed the first prototype.

Motivation

The Textales Sunny Sunday edition explores the Do-It-Yourself aspects of digital storytelling on textiles. I apply the first version of craft qualities and the first version of sustainability qualities to the design with particular attention to the qualities that involve the content creation by the end users. It was not possible to implement these qualities in the close-to-commercial Textales Dream Bear edition. By involving my group of friends, the storytelling textile canvas becomes a collection of memories. It demonstrates references to locally or conceptually important places and activities for the group. The 3D characters and other types of digital media can be added to the story at any point in time. In a way it embeds the information about the environment and the community, like the craft objects that used to carry their origin within them.

Functionality & Looks

The textile canvas demonstrates references to the main character's (Guille's) balcony where we used to enjoy long Sunday brunches, the nearby beach we liked to bike, the local restaurant where nice Sunday markets took place, an airplane as a reference connecting all our trips, and other frequently visited places with personal or group memories. Through a tablet or a smartphone, 3D interpretations of the friends themselves appear. For example Guille is happy on his balcony, Alvis is skydiving through the clouds, Domi is taking pictures and the snowmen are discovering the beach. Since the project was done without any funding, a free software application needed to be used. Junaio and CraftAR applications are used to detect images on the woven picnic cloth and project 3D characters in the augmented reality layer on top of the textile. There is a QR-code that needs to be scanned with the application before a precise figure can be found on the surface. When detected, the character can be moved and resized on the screen. These applications could be used without any financial resources by anyone, and therefore they were chosen for making a demonstration project for a community storytelling.

The canvas represents some of the key locations for a group of friends, and the characterised 3D figures play their role in the community story. The canvas and the digital data can be edited at any time. For example, a Prague landmark was added (stitched on) to the picnic cloth later in time, when some friends moved there. The digital content enhancing the fabric with their adventures was connected to the added patch. It relates back to pre-industrial crafts, when the meaning of the objects would change in time. In that way the group of friends could always keep changing.



Figure 21 Textales Sunny Sunday edition. Photography: Gordon Jack, models: Guille, Mymza, Carolina.

Meaning

Textales Sunny Sunday edition explored the aspects of craft and sustainability qualities (Chapters 4 and 5) that were not possible to implement in the commercial Dream Bear version. The characters and other content were made by Jack, Potuzakova, Rouha and myself at different times allowing the textile to develop with us and reflect on the changes in the community. They were added to the textile canvas that represented some locations with history for us. We could make, add, change and remove both the physical as well as the digital content by adding patches to the textile and creating or removing the digital characters from the channel of the application. While developing the project, we could learn new things and share the experience with friends. However, it required quite some hours of work from my friends and myself to create such content and to connect it through Augmented Reality platform providers. For example, it took me almost a full day to learn how to use the software and then to model a simple 3D flower with the help of Jack. It is also not guaranteed that the service providers would continue to maintain the application, so soon our characters might become inaccessible.

When I received an e-mail from Welspun to look into opportunities to commercialise the project with them, it looked like a possibility to finally develop the Textales that would provide professional crafted content to the users with the freedom that they could personalise and eventually create their own stories. With a small group of users and financial resources, the possibilities to develop interesting and dynamic content for the software application are limited. The offer from Welsun to bring Textales to the world through their distribution network carried a possibility of finding a larger group of users, who could support the development of new stories and characters and therefore allow the project to mature in quality.

TEXTALES LITTLE RED RIDING HOOD EDITION 2.1.3.3

Collaboration partners

Textales Little Red Riding Hood edition (Figure 22) is developed in collaboration with Unit040, Welspun and Kerstin Zabransky. Welspun India Ltd. (Welspun Group, 2013) is a fully integrated home textile manufacturer. It is one of the largest global home textile producers, with world class manufacturing facilities in India.

Unit040, Zabransky and myself continued with the roles described previously in the Textales Dream Bear edition. Welspun created the initial task with the rest of the team and produced the textile items, including the bed linen and the tufted carpet.

Motivation

With Textales Little Red Riding Hood edition, we take the project another step closer to commercialisation. The version is developed for showcasing the possibilities of Augmented Reality storytelling on textiles to potential clients. In The Little Red Riding Hood edition of Textales, parents and children share the experience of the fairy tale of Little Red Riding Hood through Augmented Reality. The Textales application running on a smartphone or a tablet device detects the patterns on the duvet, pillow and carpet and shows digital fairytale characters. Digital dynamics are combined with textile sustainability. The project team intends to improve the details of the duvet cover as well as the digital application. The images are printed to a softer textile in this iteration, and allow therefore more colours and smaller details to be designed.

Functionality & Looks

The Little Red Riding Hood story can be played with or without the subtitles suggesting the plot, as in the previous version. If the parent chooses to see the subtitles, a whole fairy tale is written throughout different scenes of the story. If the parent chooses not to see the subtitles, he can imagine his adventures for the Little Red Riding Hood and the wolf. The application has a constant forest sound in the background with occasional overriding scene-specific sound effects, such as water dropping when Little Red Riding Hood is feeding the swans, or the wolf roaring when it finds the empty house of the grandmother. The fine and detailed graphics and animations add an extra magic layer to the textile.

In the very colourful story canvas, Little Red Riding Hood goes wandering into the forests on the digitally printed duvet cover, pillow and a rug (Figure 22). The wolf has his parallel adventures. The story reveals an alternative plot and ending to the traditional fairy tale. Through that, contemporary values and ways of communicating are put into a classic fairy tale.



Figure 22 Left: Textales Little Red Riding Hood edition carpet explored by the visitors in Dutch Design Week 2015. The digital Little Red Riding Hood is captured through a screenshot from the Textales application. Right: Textales Little Red Riding Hood bed linen shown at international trade event Heimtextil.

Meaning

The adventures of Little Red Riding Hood got much more detailed and animated than the ones of Dream Bear were. Zabransky had the opportunity to create colourful detailed illustrations for the duvet cover, pillow and a carpet accompanying them, which were produced by the new collaboration partner in India. Working with one of the largest home textile producers in the world who has all the textile production steps, from cotton carding up to product packaging, in the same production facility, allowed for a wider range of products and materials to be used. They also brought their distribution network into the project. The developed story serves as a demo for finding further commercialisation opportunities.

Textales intended users

End-users benefit from the items, which belong under the umbrella of Textales. Parents can share their values through the experience of the Textales Dream Bear edition with their children. They can enjoy playtime together using the Textales Little Red Riding Hood edition. Groups of friends, colleagues, classmates, neighbors, etc. can develop and renew their stories with the Textales Sunny Sunday edition. The Textales Dream Bear and Little Red Riding Hood editions were developed as closed platforms, to exemplify the story experience that can be created through Augmented Reality and image recognition on soft textile canvas. The Textales Sunny Sunday edition was developed to explore the opportunities for a community to embed their experiences and ideas into a cloth that represents a common space for memories somehow.

Textales envisioned service

As described in the Bedtime Stories project, three levels for services occur: providing the finished story, supporting the story creation for storytellers, and supporting the story creation for the end users. The first type of service was realised in the Bedtime Stories. By developing the Textales Dream Bear edition, the second described model applies – the story was envisioned and designed by a storyteller. The rest of the team supported her creative freedom to achieve an interesting story experience. The end users got to develop their own story in the Textales Sunny Sunday edition, where a group of friends created and experience out of their adventures and common stories. The Textales Little Red Riding Hood edition was offered as a service to Welspun, who could show it to their prospective clients. Certainly an interesting development for the future is an option for the end users to add their own characters in a simpler way. For example, they could attach a photo of their dog to a pre-made 3D animal body, and through that have their personal touch in the narrative. Different stories and settings could serve different audiences, for example families, groups of friends, colleagues, classmates, etc.

Service

The potential textile development and maintenance services arise next to the digital services. They are not as well developed; however, the ideas deserve to be mentioned. The service provider (or a network of service providers) could develop a full circular system where the user leases the bed linen for the children with a limited number of cleaning times. Care service would be provided by a dedicated cleaning company, which takes care of all the chemicals and treatments used throughout the lifetime of the product, allowing it to last as long as possible.

Textales production materials, methods, tools

The third iteration of Digital Stories on Textile is woven in the case of Dream Bear and Sunny Sunday and digitally printed on a satin woven cloth in Textales Little Red Riding Hood edition. Cut & sew methods are used for constructing the items. Software is continuously developed in Unit040 by using the Vuforia platform. The decision to change from image creation through weaving to digital printing on the woven textile came as an input from Welspun, which has extensive bed linen production experience. They proposed to use soft fabrics that are gentle on children's skin while sleeping.

Materials,
methods,
tools

Textales related communication to the community & society

The redesigns of the projects combining textiles and Augmented Reality through image recognition application were shown to the community of researchers, designers and industry partners during The Art of Research 2014 conference and ArchInTex events.

Community
& society

The society outside of the immediate community has seen my presentations about the Textales projects at the Tech Sisters event in Estonia, Fashion Tech weekend as part of Prague Fashion week in Czech Republic and as part of the DRIVE: Smart meets circular session during the Dutch Design Week 2015. The projects have also been exhibited during the Dutch Design Week 2014 (Textales Dream Bear edition) and 2015 (Textales Little Red Riding Hood edition). As the projects get closer to finished-looking products, the questions they trigger in visitors change. They start to ask where and when they can buy one of the items. They stop expressing ideas and critiques about the directions the project could develop in the future. Therefore, the value of showing unfinished work that invites visitors to think along and imagine together with the designer becomes clearer.



Figure 23 First row: Felt Ball. Second row: Tender. Third row: Vibe-ing, Well-Be.

2.2 Body Sensing and Actuating Networks	2.2.1 Felt ball	
	2.2.2 Tender	
	2.2.3 Vibration Therapy	2.2.3.1 Vibe-ing
		2.2.3.2 Well-Be

Body Sensing and Actuating Networks (Figure 23) explores the interaction possibilities coming from the combination of textile materials and techniques, such as felting and knitting, and electronic components, such as LEDs and vibration motors. By merging textiles with digital properties, I intended to personalise clothing by the means of technology, hoping it would become meaningful for the wearer. Fully fashioned garments that are able to sense input such as touch, and produce output, such as light or vibration, are explored in the line of prototypes called Felt Ball, Tender and Vibration therapy.

This group of projects is motivated by allowing the garments to do more (glow light, vibrate) than is typically expected from traditional clothing. Each garment can be customised to suit an individual wearer's body, preferences and needs. The light and vibration properties can be changed through programming the electronic components. That property is envisioned to extend the meaning and longevity of garments. The use of automated zero waste production processes such as fully-fashioned knitting allows each garment to fit the wearer perfectly.

Felt Ball is the first exploration, where electronics get a soft shell, to diffuse the lights shining through the felt layer forming a ball. Tender is an expressive garment that reacts to touch sensed via the conductive integrated knit, and activates the light modules in the fitted pockets accordingly.

Under the Vibration Therapy umbrella, Vibe-ing and Well-Be both explore the emerging opportunities from the combination of integrated knitted touch sensors and activating vibration motors. The prototypes are proposed to be used in wellbeing areas especially for long-distance self-care (Bhömer, Jeon, & Kuusk, 2013).

With the Body Sensing and Actuating Structures, we explore the possibilities of having a programmable textile that can change its behaviour over time. The textile could be a communication means, such as the Felt Ball, a fashion piece with light effects, such as Tender, or a rehabilitation tool with programmable vibration patterns, such as Vibe-ing or Well-Be. Throughout these examples, the technology becomes more harmoniously integrated with the textile. Each of them shows opportunities and challenges that appear when integrating light into felt and knit, or vibration into knitted and felted garment.

Body Sensing and Actuating Networks projects are mainly developed as demonstrations. They are meant to be used in exhibitions, where they show the possibilities of smart textiles to actors in different areas, such as health care professionals, textile designers, care givers in elderly care organisations, policy makers etc. Here, on the one hand, designers and engineers working on the prototypes provide a service to the interested parties by physically providing possible interest areas for a starting conversation. On the other hand, the connected garments with their networks would offer possibilities for services provided by care givers, insurance organisations, maintenance, digital tailors (fitting the custom made garment and custom programmed electronics), after life re-makers, etc.

Levels of integration of textiles and technology in Body Sensing and Actuating Networks

The Body Sensing and Actuating Networks category fits the integration category, where Köhler (2013b) talks about electronic devices that are to be seamlessly incorporated, for example embroidered. The Second category Os (2013) defines as weaving or embroidery, remove before wash, hybrid technologies and traditional electronics. He uses the MP3 sports jacket as an example of this category.

The level of integration of textiles and technology in Tender, Vibe-ing and Well-be, as part of the Body Sensing and Actuating Networks, is integrated as the knit-work has specially designed pockets for the electronics to fit in, and the microchips with the 3D printed vases are specially constructed for the knitted pockets on the body. The power and information runs throughout the garment via the coated silver threads that have been knitted into the piece with the textile yarns.

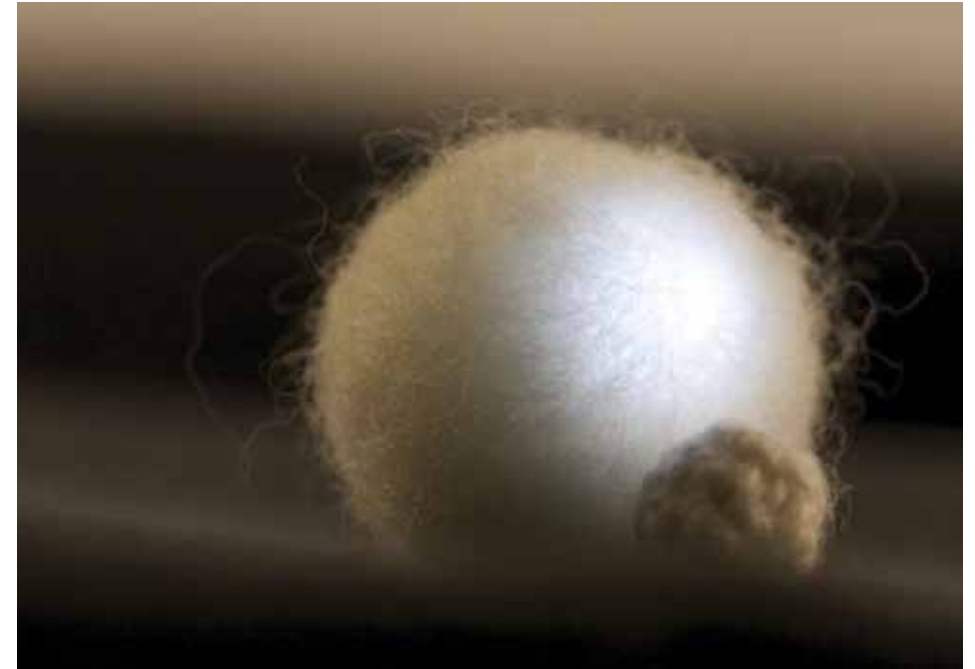


Figure 24 Felt Ball, the first attempt to embed electronics into textile through felting wool around it.

Video Video introducing Felt Ball: <https://www.youtube.com/watch?v=pxFi5KzUHAc>

Collaboration partners

Felt Ball is developed in collaboration with a colleague, Martijn ten Bhömer (Bhömer, 2015), who is looking into how to design embodied smart textile services in his PhD research at Eindhoven University of Technology. We conceptualised and produced the felt balls together.

Motivation

Felt Ball represents a concept of different kind of communication over distance, where the ball would copy behaviour applied to it by one person to the other “twin” ball. We made Felt Ball as a very first exploration in TU/e collaboratively with a colleague, to find out what we could exchange from our backgrounds in fashion design and interaction design. Bhömer learned about needle felting, and I experimented with Arduino programming. The electronic components felted into a ball were connecting several soft balls through magnetic fields. The envisioned direction for the Felt Balls was to use them in communication over distance.

Functionality & Looks

The Felt Ball has a magnetic switch, battery, felted battery-clip, 2 LEDs inside, and this simple prototype represents the glow that could be transferred through the felt surface. Another experimental Felt Ball changed its colours according to different patterns while being connected to an Arduino. Aesthetically, the light diffused through white felt, that is needle dry felted into a ball, glows very subtle. It’s an attempt to soften light through textile technique. Light is the most effective and easy property for prototyping simple interaction. People can easily see and relate it.

However, we wanted to bring it closer to the body and therefore make it softer and subtler.

Meaning

Many integration problems occurred when trying to combine hard electronic components with soft wool through felting. For example, it is very difficult to find a robust but clean way for connecting conductive threads to a battery. We could discover different ways of connecting components that usually need to be soldered to textile components by sewing, crochet or felting. The conductive threads, for example, could be felted into a wool pocket in which the battery could rest. The manual time-demanding processes limited us from making larger items and surfaces. With the next iteration, Tender, we looked into how the electronic materials could be embedded to knitted textile during the industrial knitting process itself, which allowed for larger surfaces and more explorations on the body.

Felt Ball's intended users

Users

Felt Ball is an explorative try-out to bring together the softness of textile - wool in particular - and interactive properties of electronics. It becomes a conversation piece or a meaning exchange tool between the stakeholders. We could talk through the material with Bhömer and share our understanding of the potential of the technology with the community around. Therefore, the main users benefitting from Felt Ball would be the makers and possible further developers and they would use it as a proof of concept and a conversation tool.

Felt ball envisioned service

Service

The service model where the Felt Ball could be implemented would be about sending visual communication data over distances. The light behaviours picked up on one side could be transferred to the receiver. Different patterns could be provided for the end users. Perhaps the light would reflect the noise or music patterns in different environments. Therefore, it could serve as a connecting platform between people over distance and interaction designers.

Felt ball production materials, methods, tools

Materials,
methods,
tools

In creating the Felt Ball we used wool, magnetic switch, magnet, LED and Bekinox conductive thread. The wool was dry needle felted around the LED and battery. The connections between electric wires, LED and Arduino required soldering and the connections between wool, conductive threads and battery some hand sewing.

Felt ball related communication to the community & society

Community
& society

Felt Ball was demonstrated among colleagues in the Eindhoven University of Technology, but not externally.



Figure 25 Tender. Photography: Hanneke Wetzer & Bas Berends (Studio HUID & HAAR), Hair & Make-up: Jaimy Bontenbal, Model: Malou Verheijen.

Collaboration partners

Tender is developed in collaboration with Martijn ten Bhömer, Paula Kassenaar and Jesse Asjes (TextielMuseum, 2015) and Metatronics (Metatronics, 2015).

Together with Bhömer and Kassenaar we envisioned and ran the project. I did the garment design and the tailoring of the garment. Bhömer developed the hardware and the software. Asjes developed the textile. Metatronics developed and produced the modular hardware components.

Motivation

Tender was developed to explore the combination of stroke sensitive and light reactive material. Tender is a garment that reacts to stroking. It lights up separate pockets on the body according to how they have been in contact with the skin. By stroking the garment, it is possible to 'move' the lit part of the wearable. Stroking can be used to gather light around the neck, chest area for reading, and hands area for a spotlight to find something in the dark or for other playful effects.

Functionality & Looks

Tender is a garment that exhibits a structural knit textile that incorporates programmable microchips in each pocket integrated into the material. It can be programmed to react to different inputs, perform a range of actions and give desirable output. Touch-sensitive garment is one of many possible applications of the developed textile. Each module is a separate entity and senses when it has been touched. It registers the connection with the human skin, and therefore only works on the body. Tender is a combination of structural knitting, electronics and conceptual fur-bubble inspired look. It suggests the soft light and personalised interaction to be the luxury of today.



Figure 26 Tender as a garment sensing and reacting to touch. Hair & Make-up: Hilda Jonkman, Model: Maaïke Reus.

Video Video introducing Tender: <https://vimeo.com/51436809>

Meaning

Knitting Tender with a fully-fashioned knitting machine that had to combine cotton threads with copper wires, showed the project team the possibilities and limitations for such a hybrid prototype. For example, we could only knit straight lines with the copper wires. It showed us the importance of creating the garment by combining smaller panels. This way we could place the modules more flexibly around the body. The light in the garment had a very strong effect and was immediately understood by the audience. The garment was shown at several catwalks and exhibitions. It also made us reflect on the desire to be glowing in the dark. We got curious about the other senses, and especially, what benefit could vibration, which is distributed around the body, bring? Also, the vibration can be felt on the body, while the light can only be seen.

Tender's intended users

Tender brings the textile softness and knitting together with the technological interaction possibilities. We as a project team used light as the output because it is noticeable, clear to communicate and engages people's attention to think of other possible uses. Therefore, in the case of Tender, the primary envisioned users are the project team and possible future collaborators. It becomes a tangible communication platform, where different expertise can come together and learn from each other.

Tender's envisioned service

A service provider could lease Tender to end-users. It is such a complex combination of textile and electronic components that it would need special care to be maintained over a longer time. It might require smaller fixes and adaptations in time. Therefore, the ownership of such a garment should stay with the producer or the service provider. They could provide different light patterns, different designs for various use cases. For example, one garment could have lounge, candle and party modes, which would react differently to stroking. Also the strength of the required stroke could be personalised for the user.

Tender's production materials, methods, tools

Materials: cotton yarn, lycra yarn, elastic rubber, polyester thread, Elektrisola textile wire, Bekinox conductive thread, LEDs, CRISP LED modules, battery. Techniques: Stoll knit & wear knitting, overlocking, hand sewing, soldering, programming. Tools: Stoll knitting machine, sewing needle, overlock, soldering iron, computer.

Tender's communication to the community & society

Tender was presented to the community of researchers, designers and industry partners through presentations and publications. For example, it was analyzed in a sustainability context in Ambience 2014 and as part of E-textiles Swatchbook at ISWC 2014.

Tender was actively shown outside of the immediate community in events such as the Pretty Smart Textiles exhibition in Belgium, during Dutch Design Week 2012, Night of the Nerds. The interest at external exhibitions and events showed the development team the potential of using light as an attractive conversation starter.

Users

Service

Materials,
methods,
tools

Community
& society

2.2.3 VIBRATION THERAPY



Figure 27 Vibe-ing. Photography: Hanneke Wetzter & Bas Berends (Studio HUID & HAAR), Hair & Make-up: Jaimy Bontenbal, Model: Jos van der Weele.

Vibration therapy groups together projects for individual well-being: Vibe-ing and Well-Be (Well-Black and Well-Blue). They explore the concept of having garments that can be programmed to behave (light up, vibrate) in a certain way. While developing the examples, our main motivation was to explore, through making, the limitations and opportunities for textiles embedding electronics.

Vibe-ing, Well-Black and Well-Blue react to the way they have been touched with programmed vibration patterns. The pressure provided by vibration motors in the knitted pockets can be pre-programmed by a therapist or react to the immediate touch of the person wearing it, allowing several options for the emerging service element.

The garments are knit in a fully-fashioned knitting machine that delivers the textile components according to specified markers in panels. For example, a piece for a sleeve can come out from the machine already in a suitable shape. That means there is no cutting waste for making the garments. They come together based on the requirements for the vibration motor locations. The panels are designed to fit the construction of the final garments and therefore no additional waste is created.

VIBE-ING 2.2.3.1

Collaboration partners

Vibe-ing (Figure 27) is developed in collaboration with Eunjeong Jeon, Martijn ten Bhömer, Jesse Asjes (TextielMuseum TextielLab), Admar Schoonen (Metatronics). Credits: Chet Bangaru, Daisy van Loenhout.

Jeon is a designer, researcher focusing on comfort of materials close to the body. She made sure the garment would support the wearer's well-being. Bhömer developed the hardware and software for this project. Asjes contributed with her knitting expertise in TextielMuseum TextielLab, Schoonen contributed with his expertise about electronics. Bangaru fabricated the 3D printed cases inside which the vibration motors are placed. Loenhout helped the team to make a duplicate of the prototype. My role was the garment design and the tailoring of the prototype.

Motivation

Vibe-ing is developed to explore the possibilities of a self-care tool in the form of a garment. It invites the body to feel, move and heal through vibration therapy (Bhömer et al., 2013). The aim of this design is to inform a multi-disciplinary audience about the opportunities of integrating vibration motors into textiles for self-care at home during everyday activities.

Functionality & Looks

The merino wool garment contains knitted pockets embedded with electronic circuit boards that enable the garment to sense touch and vibrate specific pressure points on the body (Figure 24). Merino wool was used for its soft and fluffy feeling. It was felted after the knitting process to create a bulky structure comfortable to touch and wear. By integrating vibration actuators in textile pockets in 3D printed casings, the design enabled programming the exact areas and the way of stimulation on the body depending on the specific person's need for rehabilitation and healing. The programmable motor boards that are fitted into the pockets allow the garment to change its stimulation behavior according to the personal needs of the wearer. The vibration strength for the prototype was chosen by exploring different vibration possibilities in the combination with the soft material.

Using fully-fashioned manufacturing techniques, it becomes possible to customize the garment to the preferences of an individual body. For example, each body type needs the vibration motors in slightly different locations on the body. The pockets can be situated in locations needed for that particular body type for the specific therapy. The effective silver coated wires running between the pockets carry information as well as energy, and show the technical character of the garment to the viewer. With this prototype, all the electronic modules are connected to each other, being able to send and receive information from and to each other. That allows for different interaction possibilities. For example when a sensor on a shoulder is touched, perhaps one on the back will react to that touch. The garment is also designed to be worn in four different ways depending on the need of the person.



Figure 28 Well-be as a self care tool that senses touch and has vibration modules in integrated pocket knit.

Video Video introducing Vibe-ing: <https://vimeo.com/78330627>

Meaning

Embedding vibration motors that are able to change their behaviour into a garment showed us an opportunity of using clothing as a self-care tool. It gave an idea how a medical instrument could be warm and soft instead of cold and hard, while retaining the benefits of the technology. The concept helped to raise self-awareness through touch and self-care through the vibration therapy. To explore the possibility further, the team wanted to look into some acupuncture areas in order to place the vibration motors more strategically on the body. Therefore we designed Well-Be separately for a male and a female body.

2.2.3.2 WELL-BE

Collaboration partners

Well-Be is developed in collaboration with Martijn ten Bhömer, Oscar Tomico, Jesse Asjes (TextielMuseum TextielLab Tilburg), Admar Schoonen (Metatronics). Credits: Chet Bangaru, Daisy van Loenhout, Silvin Willemsen, Bregje Brockem.

Other team members continued with the responsibilities described in Vibe-ing project. Willemsen and Brockem helped the team to produce the prototype. Tomico designed the Well-Blue garment.

Motivation

Well-Be is developed to explore further the material properties when working with fully-fashioned knitting and vibration motors. As with the preceding Vibe-ing, Well-Be is a self-care tool for well-being. Through stimulating selected acupuncture points on the body, the garment allows for subtle exploration and connection with oneself. Well-Black (Figure 25) has been designed for a female body and Well-Blue (Figure 26) for a male body.

Functionality & Looks

Both garments are constructed from panels knitted by a fully-fashioned knitting machine, which potentially allows for the use of zero-waste practises in the future. Both prototypes have several CRISP motor boards embedded in specially designed 3D printed cases placed in the knitted pockets in the main acupuncture areas of the body. The garments invite touching. The vibration motors activate based on pressure and touch applied to them.

The symptoms listed below are examples and intended to be used as inspiration to see what could be done with such a combination of textiles and technology on a textile construction level.

Some of the pressure points stimulated by Well-Black (Figure 29) are: 1. around the tip of the shoulder, which relates to neck pain, shock, shoulder pain, arm pain, bruises, exhaustion, fatigue, head injury or pain; 2. between the two most prominent bones of the top of the spine, which can have an influence for cough, fever, flu, headaches, hives and rash, immune system, neck, nosebleed; 3. in the back waist area that relates to general and upper backache, haemorrhoids, hiccough, hypertension, nausea, sciatica, stomach, vomiting and retching. (Boyd, 2011) For example, by massaging and stimulating the shoulder tip area, neck pain could be reduced.

Well-Black

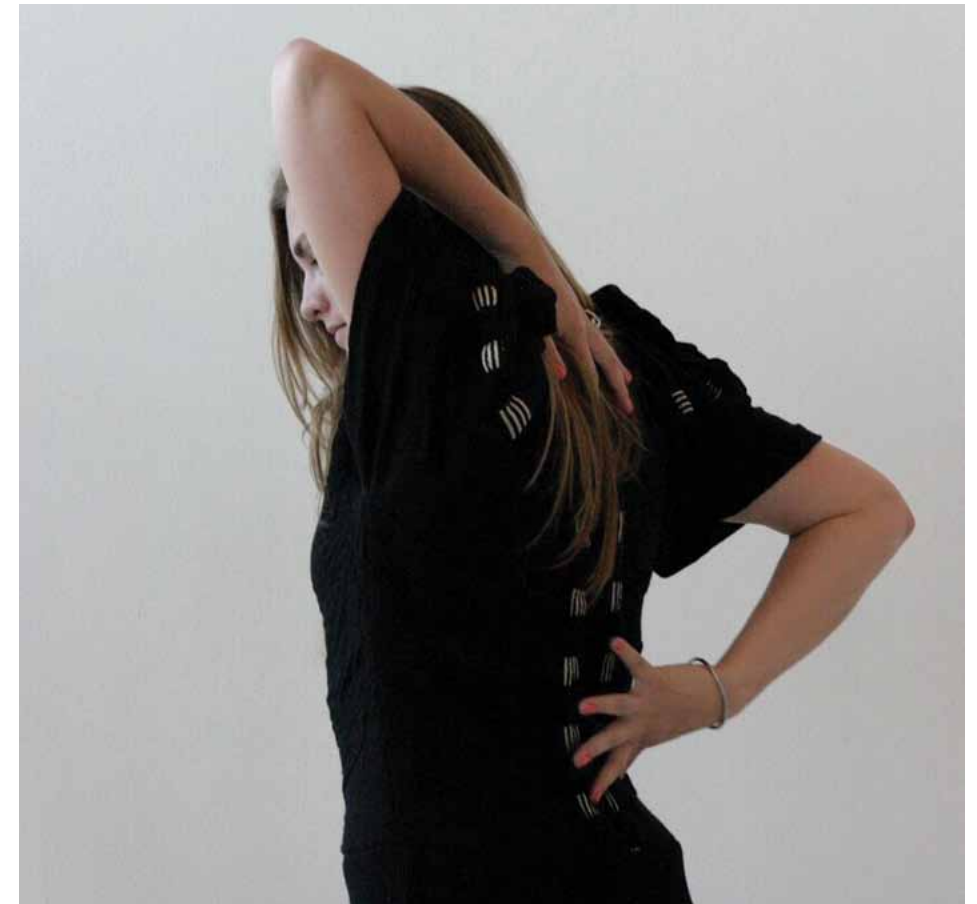


Figure 29 Well-Black as a self care tool for women. Model: Marieke de Sain.

Some of the pressure points stimulated by Well-Blue (Figure 30) are: 1. between the two most prominent bones of the top of the spine, which can have an influence for cough, fever, flu, headaches, hives and rash, immune system, neck, nosebleed; 2. in the back waist area that relates to general and upper back ache, haemorrhoids, hiccough, hypertension, nausea, sciatica, stomach, vomiting and retching. (Boyd, 2011) For example, by massaging the back waist area, general back ache could be relieved.



Figure 30 Well-Blue as a self care tool for men. Model: Michiel van Zummeren.

Meaning

By developing Well-Be examples, the project team could refine the techniques and technology for knitting, connecting and programming the pieces and different components for the Vibration Therapy garments. The smart textile examples are ready to be developed further with health care professionals. They can be used as conversation tools to find directions for soft knitted medical support accessories.

Vibration Therapy's intended users

Vibe-ing, Well-Black and Well-Blue are used in exhibitions to demonstrate the possibilities of smart textiles to therapists in the health care area, as well as opportunities to work in the care area for the smart textile developers.

Users

Vibration Therapy's envisioned service

Assuming the prototypes would be developed into final products, there would definitely need to be services supporting the personalisation and maintenance of the garments. To be used in the self-care area, the care patterns should be developed and communicated to the users. The progress of each user should be monitored by a care professional and instructions fed back to the user through the garment. The garments would need to circulate between different users, to be used to their maximum material life.

Service

Vibration Therapy's production materials, methods, tools

The prototypes bring together expertise from textile as well as electronics development. The materials used in the project, such as merino wool yarn, Lycra yarn, elastic rubber, polyester thread, Electrisola textile wire, Bekinox conductive thread, vibration motors ROB-08449, CRISP motor board, battery 2000mAh 3.7V 7.40Wh, 3D printed casings are not commonly integrated into one garment. It takes Stoll knit & wear knitting, felting, overlocking, hand sewing, soldering, 3D printing, programming expertise to realize the Vibration Therapy garments.

Materials,
methods,
tools

Vibration Therapy's related communication to the community & society

Vibe-ing and Well-Be have been introduced to the community of researchers, designers and industry partners in conference publications in Ambience'14&10i3m and DeSForM 2013, as well as in a journal article in Materials & Design. They have been shown in the Smart Textile Salon to exchange ideas with fellow smart textile developers and ArchInTex network events to communicate the work and receive feedback.

Community
& society

The Vibration Therapy prototypes have been shown to general audiences outside of the immediate community in presentations and exhibitions, for example: Prague Fashion Weekend: FashionTech, Dutch Design Week 2013, 2014, Beijing Design Week, Dutch Technology Week, Smart Flexibility: Advanced Materials and Technologie travelling exhibition.

2.3 THERMOCRAFT

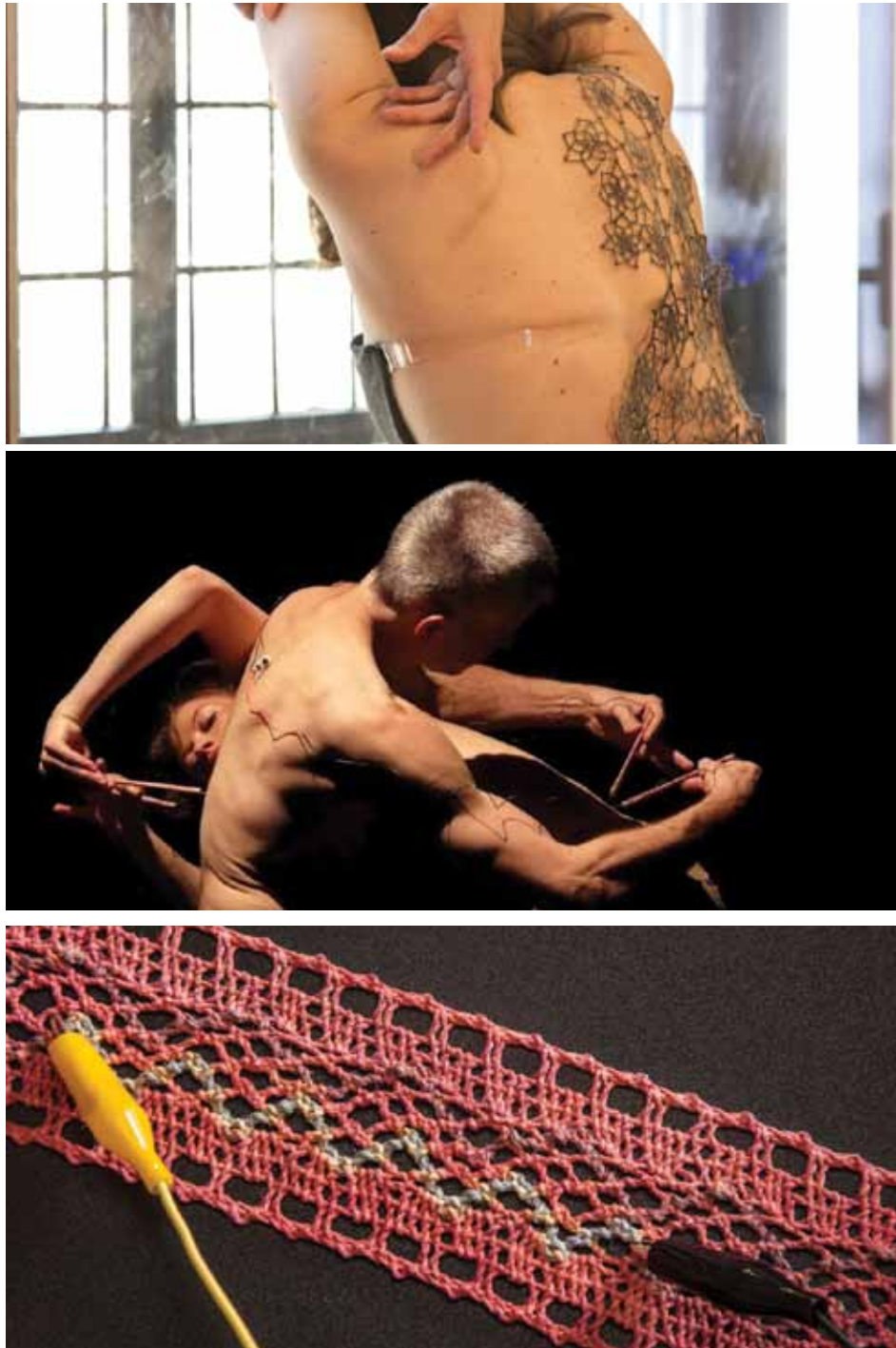


Figure 31 First row: CHACUN(E). Second row: YB-ML. Third row: Butterfly Lace.

2.3 Thermocraft

2.3.1 CHACUN(E)

2.3.2 YB-ML

2.3.3 Butterfly Lace

Thermocraft (Figure 31) explores the traditional property of textile to fade or change colours in time and while exposed to the UV-light. In this project, the process is speeded up, but the notion of tracking and awareness of time remains. Thermo sensitive pigments change colour according to the temperature change in their environment. It explores playful colour change in knitted, crocheted or lace textile worn by dancers. Each piece in this project group is unique and personalised for a specific user and an occasion.

The motivation for the projects was to bring slowness and values related to crafting closer to busy people through smart textiles and new materials. The colour change in the thermosensitive threads and yarns is slow and subtle. It can be noticed only when observed closely and with the attention directed to it. This allows for designing very intimate and subtle interactions.

In CHACUN(E) the crocheted textile, being treated with thermosensitive pigments, changes colour depending on the ambient and body temperatures. In Your Body My Landscape (YB-ML), the conductive thread, treated with thermosensitive pigments, acts as a tool in the choreographic process. It can be controlled by the current applied to it. In the Butterfly Lace the yarn, which is treated with thermosensitive pigments, acts as a sensor as well as an actuator. It is able to change its colour into several states according to how it has been touched.

Thermocraft is a concept to explore thermosensitive yarns creating dance performance pieces. It has been used as a costume in one performance: CHACUN(E) by Angelina Deck, which was based on music by Bach and performed in London as well as in The Hague; and as a choreographic tool in another performance: YB-ML by a choreographer, Gyula Berger, and a contemporary dance theatre performer, Roos van Berkel, and performed in Budapest. In the case of CHACUN(E), the performer used body heat to trigger the colour change of the dyed wool and viscose yarn crochet, and in the setting of YB-ML, the choreography was based on the heating properties of a conductive thread crochet. Both designs were custom-made for the particular performer and act to explore the properties and opportunities that thermosensitive yarn construction could open up for performance arts. Butterfly Lace has been shown in exhibitions to trigger a conversation about the possible uses for such crafted technology.

Thermocraft projects are mainly developed with performative settings in mind. The dance costumes have been used to communicate the concepts and ideas of dancers to the audience during a stage performance. The technological costume makers would certainly find a service to offer here. Also customising or renting services would be possible, since the stage clothing would be used only for a certain period. The same garments could be worn in special events and galas, as effect-wear.

Levels of integration of textiles and technology in Thermocraft

Thermocraft comes closer to the combination generation described by Köhler (2013b) as the textile materials and structures with inherent electronic functionality, such as yarn transistor, fiber-based circuits and photovoltaic fibers. Also Os (2013) recognises the Third category where he groups the functional fibers, solar or LED or OLED and functional fabrics. Here he brings

an example of Solar Fiber (Hoitink, Jacobs, Toeters, & Grant, 2012), that basically is a flexible photovoltaic fiber that converts sunlight energy into electrical energy.

The yarns used for constructing the pieces in Thermocraft are dyed using thermo-sensitive pigments. In some cases, the textile fibers are mixed with high conductive metals, such as silver or copper or stainless steel, thereby becoming electroconductive. The yarns are crocheted into costume parts or made into a lace structure, therefore the textile and technological parts get very difficult to separate, which could potentially be a problem for disposal and recycling.



Figure 32 CHACUN(E) as an exploration into thermosensitive yarns on a body in performance context.

Collaboration partners

CHACUN(E) (Figure 32) is developed in collaboration with Angelina Deck. Deck is a dancer and choreographer, who took up the challenge to experiment with a thermosensitive top while creating a new performance piece, CHACUN(E).

I designed the top based on our first discussion with Deck. Our ideas were synchronised about the shapes and materials for the performance costume. I produced the top based on the insights we gained after trying parts of the top on and Deck rehearsing the choreography holding the material close to the body.

Motivation

CHACUN(E) is designed as a performance costume that would change its colour based on the ambience or the body's temperature fluctuation. My motivation was to explore what would happen with the colour-changing concept on stage; how would a dancer give meaning to it and transfer that meaning to the audience? Deck was exploring the internal movement, potential and intelligence in this work. The project experiments with the use of thermosensitive pigments on

yarn and thread level to discover the possibilities and challenges that come with it. The structure of traditional crochet and the dancer's body movement change the colour on the costume. She becomes aware of her body temperature and can react to the playful, subtle colour change created by her movement.

Functionality & Looks

The garment reacts differently during every performance due to difference of movement, ambience, weather, dancer (Figure 33). For example, if the dancer's body warms up, the threads closer to her body change colour, the ones more distant do not. It creates a very close and intimate unique, non-recurring interaction between the dancer and the costume. The detailed crochet motives change from black to different colours on the dancer's body based on her body temperature change, which is closely related to the choreography (Figure 34). The playful play of colours



Figure 33 Left: CHACUN(E) in a dance rehearsal, photography by Dominika Potuzakova. Right: CHACUN(E) at Wearable Art gala, photography by B. Jonathan Michaels Photography.



Figure 34 Left: Thermosensitive corchet shapes revealing different base colours. Right: Deck at a dance rehearsal wearing the CHACUN(E) top.

Video from the performance: <https://www.youtube.com/watch?v=trnePO1GKbk>

is mainly visible for the dancer herself. The audience can only experience her movements that might be influenced by it.

The costume consists of crocheted snowflake shapes, which are dyed with thermosensitive pigments and connected by hand stitches to one another. They move together with the dancer's body and transform the shape of the costume, pattern and sizes of the flakes. Through the temperature change in the ambient or dancer's body, the thermosensitive black colour becomes transparent, revealing the original colours of the yarns used to crochet the snowflakes.

Meaning

I developed CHACUN(E) as a hobby project trying to follow my intuition and desire to work with thermosensitive materials at the yarn level. Deck used the piece in the performance and shared her insights into how the subtle colour change that appeared because of her changing body temperature also guided her choreography. This was something completely unexpected for me. I was curious to see the possible application for similar construction with conductive materials that could be also controlled by electronics. Since body temperature cannot be manipulated very reliably, the electronics could help to give the dancer the security of knowing what will happen and how it will happen during the performance. That's what we explored in the next project.

CHACUN(E)'s intended users

CHACUN(E) is used by Deck, the dancer. She uses the top during the building up of the choreography as an inspirational tool, and as a costume during the performances. She allows the material to interact with her through the more improvisational parts of the performance. The audience watching the performance does not see the subtle colour change, however it experiences it through the movement of the dancer.

Users

CHACUN(E) envisioned service

There could be a service providing such costumes to dancers, performers and other users who wish to have subtle colour change near their body. They can be prepared on a made-to-order basis for individual buyers. Later some themes would emerge and allow more common traits to be translated into a product for smaller series. The garments can be also leased to performers, as they would be used for a relatively short time. In this case the material can be reworked into new costumes and objects.

Service

CHACUN(E) production materials, methods, tools

For CHACUN(E), I hand-dyed cotton, wool and viscose yarns with black thermosensitive pigment with the activation temperature 27°C. I crocheted the yarns into small snowflake-shaped motifs and connected them to each other by hand using a polyester thread. Grey tricot fabric was used for the front part of the top.

Materials, methods, tools

CHACUN(E) related communication to the community & society

The project has been communicated to the community of researchers, designers and industry partners through the Ambience'14&10i3m conference publication in the context of analyzing three smart textile service proposals for sustainability.

Community & society

The project has been presented to others outside of the immediate community during some presentations, for example FashionTech in Prague Fashion Weekend. But more importantly, Deck has performed the piece in London and the Netherlands. It has been shown as one of the selected pieces in the Wearable Art Gala and Wearable Art Exhibition in Saskatchewan.

2.3.2 YB-ML: THERMOSENSITIVE CONDUCTIVE YARNS



Figure 35 Gyula Berger and Roos van Berkel during dress rehearsal for the choreography 'Your body – My landscape', Oct 2013. Photographed by Kristián Fehér. More information: <http://ybml.wordpress.com/>

Collaboration partners

The application of the threads for YB-ML is developed in collaboration with Roos van Berkel, Gyula Berger and the scenographic team of the production. Credits: Lucas Bernardes Naves, Lotte de Leeuw (Saxion University of Applied Sciences).

Berkel is a teacher and performer focusing on dance, performance art and interactive technology (Berkel, 2014). Berger is an internationally renowned choreographer and one of the founding members of the contemporary dance scene in Hungary (Berger, 2013). Berkel and Berger, with their team, envisioned and created the choreography. My previous work with thermosensitive yarns served as an inspiration for this development. I consulted the scenographic team and helped to produce parts of the costume. Naves and Leeuw helped to research and try out different methods for dyeing thermo sensitive yarns.

Motivation

The conductive crocheted textile was created to be used during the creative process of the choreography 'Your body – My landscape' (Figure 35). The dancers explored different applications of the conductive crocheted textile, curious as to how these explorations would stimulate the scenographic as well as the choreographic development of the work. The costume (Figure 32) was used by the dancers to build up parts of the scenography, while they reflected on how the use of such material informed their choreographic practise and how the interaction with the threads might inform the use of the material from a design perspective.

Functionality & Looks

The costume shown in Figure 36 has crocheted conductive thermosensitive lines on top, which can be heated up by the dancers through the needles they are holding in their hands. The needles are connected to a power supply that sends 6V of current through the thread. The thread changes its colour from black to grey because of the heat created by the resistance in the yarn conducting electric current. The dancers use the long needles to activate the areas influenced by the current on each other's bodies (Figure 36). The choreographed movement is set through the functionality of applying power to small lines on the garments.



Figure 36 YB-ML performance. Photography: Róbert Révész & Kristián Fehér.

Meaning

YB-ML and the work with Berkel gave considerable insights into how conductive thermosensitive materials could inspire performance curating. Berkel and Berger used long theatrical needles to activate the colour change on each other's body. I started to wonder, what if the same yarns could be controlled by human touch itself and what if they could reveal several colours instead of only one.

Departing from the concept of creating traces, the choreographers and performers sought to visually create a landscape on each other's bodies and/or create traces in the surrounding décor. The element of time was the key to the creation of movement material as well as using the fabric – the choreographers were fascinated by how the effect of the colour change was determined by time in unpredictable ways, and how the interaction with the fabric created new possibilities for the composition with regards to playing with movement and stillness.

YB-ML's intended users

During the creative process of YB-ML, various applications of the conductive thread were explored – this informed and partly steered the development of choreographic material. During the research phase of the project, the dancers playfully interacted with the material and allowed it to speak back to them.

YB-ML's envisioned service

To use thermosensitive conductive materials for building a choreographic piece, the costumes or smaller elements could be leased to professional dancers, who would use them for inspiration and return them after the sessions. The service system supporting such exchange could create the performative inspiration tools on order or offer different materials, combinations and ideas for such body brainstorming.

Users

Service

Production materials, methods, tools

Materials, methods, tools To make the colour-changing crochet lines for the costumes of the dancers I crocheted light grey 80% polyester 20% stainless steel conductive yarn Nm10/3 and dyed it with black 27C thermo sensitive pigment.

YB-ML related communication to the community & society

Community & society The project has been introduced to the community of researchers, designers and industrial partners within the *Ambience'14&10i3m* publication reflecting on the sustainability of three smart textile service examples.

Society in general has seen the dancers performing their piece in Germany, Hungary, Transsylvania, Romania and the Netherlands.

BUTTERFLY LACE: SENSING AND ACTUATING THERMOSENSITIVE MULTICOLOUR YARNS 2.3.3

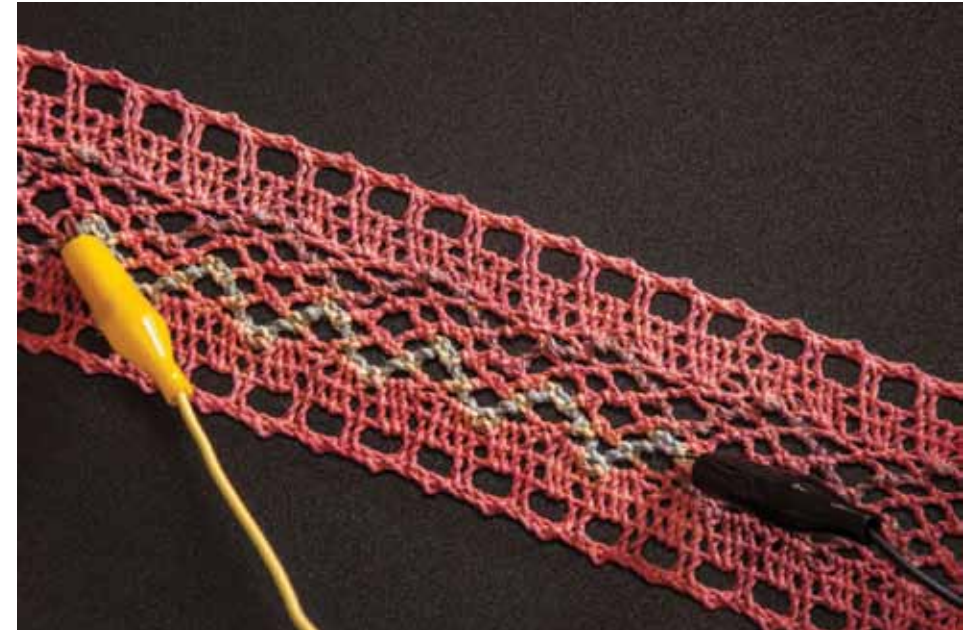


Figure 37 Butterfly Lace as a sensor and an actuator in one yarn.

Collaboration partners

The Butterfly Lace was developed in collaboration with Museum de Kantfabriek, Marjan Kooroshnia (The Swedish School of Textiles) and Jussi Mikkonen (Aalto ARTS). Kooroshnia is a doctoral student in the field of textile design where she focuses on exploring design properties of smart colours on textiles (Kooroshnia, 2014). Mikkonen is a lab manager of the embodied interaction lab, and a member of the embodied design group, at Aalto University, school of art, design and architecture. His research interests are in wearables, personal electronics and prototyping (Mikkonen, 2012). Museum de Kantfabriek (Museum de Kantfabriek, 2015) celebrates the art of lace making by having machines from the previous century still working in their facilities.

I brought the idea and prior examples to the project. Museum de Kantfabriek produced the lace with the conductive yarn in its structure. Kooroshnia contributed with her expertise and skills in thermo sensitive materials. Mikkonen developed hardware and software for this project.

Motivation

In Butterfly Lace (Figure 38), we connect the concept of CHACUN(E) (thermosensitive yarns) with the concept of YB-ML (thermosensitive conductive yarns) to create beautiful interactive structures that can be programmed to react differently to a human touch. It is a conductive multi-colour sensor-actuator structure that lies in the intersection of traditional craft and smart materials. Butterfly Lace reflects the property of any traditional textile by changing colour in time while being exposed to the UV-light. The pace of the change is different. The lace was produced in the Museum de Kantfabriek using machines from the 1930s. The technique of lace making is interesting because it allows every thread to be manipulated separately. By choosing

a strategic pattern, the conductive threads can either run in parallel if needed, or contact each other. They can be controlled separately if they don't connect to each other in the lace structure. Another interesting aspect about using the machine lace is that unlike the crochet, which has been used in previous iterations, lace can be machine produced in larger quantities.

Functionality & Looks

The developed lace senses how it has been touched, and outputs a programmed behaviour. The conductive yarn in the lace structure acts as a sensor and an actuator at once. After detecting the touch, it warms up to a certain degree and causes the thermosensitive pigment to change the colour accordingly (Figure 39). The colour mix is optimised to show violet-blue at ambient temperature, orange at 27°C, yellow at 37°C and grey at 47°C.

Butterfly Lace combines a sensor and an actuator in the same structure. The conductive yarn detects the human touch and the attached electronic module heats the yarn to a certain temperature to reveal the defined colour palette. The lace structure is used for the property of controlling each yarn independently. Each separate thread of the structure can sense the user input and display a different colour accordingly. In this way, the traditional textile technique defines the interaction behavior of the smart textile. The thermosensitive properties in yarn level can be used to make a yarn appear or disappear (Figure 40).



Figure 38 Butterfly lace, that heats up an integrated conductive yarn when touched. The temperature change causes the yarn in the thermosensitive lace to change colour.

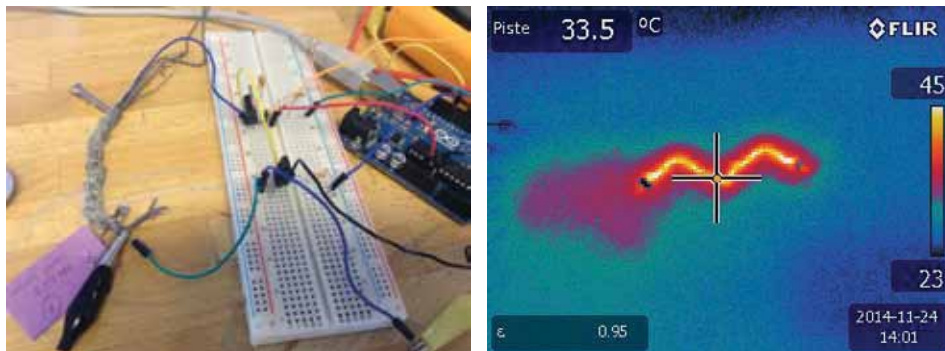


Figure 39 Steps from the Butterfly Lace development process. Arduino is heating up the conductive structure and the temperature change observed through a heat camera.

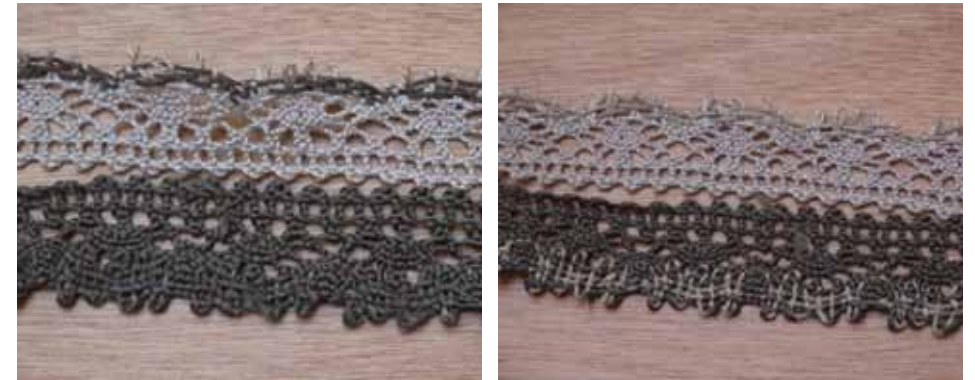


Figure 40 Left: a lace with thermosensitive yarns in ambient temperature, right: the same lace heated above 37°C.

Video introducing Butterfly Lace: <https://vimeo.com/140340625>

Meaning

The development of Butterfly Lace took the combination of conductive yarns, traditional lace making and thermosensitive colour change to a new level. The industrially produced lace, with conductive threads, became a sensor and an actuator in the same textile. Next we would like to try to implement the developed technology next to the body, also in interior design and larger surfaces.

Butterfly Lace's intended users

Butterfly Lace is used in exhibitions to demonstrate the possibilities of sensing and actuating lace structure. The primary user of the lace, therefore, is a designer or other possible future project partner wishing to work with the technologies and materials incorporated in the concept. At the moment, it is used as a sample to communicate the concepts. The authors envision applying the technology in interior design in due time.

Users

Butterfly Lace envisioned service

Butterfly Lace demonstrates the interaction possibilities for the combination of traditional craft, conductive yarns, thermo sensitive dyes and electronic system. The service element at the moment is the information exchange and distribution between the development team and to the outside. Being used by an end user, the interactive lace could function as a soft user interface.

Service

Butterfly Lace production materials, methods, tools

The light grey conductive yarn Nm10/3, 80% polyester 20% stainless steel and grey viscose crochet threads, were constructed into a lace using an industrial lace machine from the 1930s. The lace was dyed with a black thermosensitive ink with activation temperature of 27°C. Arduino, electric wires, soldering tin, resistors, transistors, and LED were used in a box to control the behavior of the lace. The Arduino was programmed to sense the human touch on the conductive threads and react to it, by heating the threads up to a certain temperature.


Materials,
methods,
tools

Butterfly Lace related communication to the community & society

Butterfly Lace has been shown to the community of researchers, designers and industry partners during the ISWC 2015 conference and ArchInTex exhibition. The concept makes people wonder whether and how they would like to wear it.

Community
& society



 Scan the image with the Textales LRRH app!

DESIGNING WITH CRAFT 3

INSPIRED SMART TEXTILES

CHAPTER

3

The first-person experience of designing craft inspired smart textiles provided a designer insight into the complexities of combining two separate worlds of textiles and technology in different levels in multidisciplinary teams. The current chapter introduces material as a combination of technology, textile, culture and personal history. It gives background on how material is seen as a driver in craftsmanship approach and design research. It points out the reasoning and experience of discovering each of the combinations of textile and technology that are present in the Portfolio (2) projects. The chapter also shares my insights about working with the material through touching it and being touched by it at the same time. It explains my cultural motivations and way of using tools, sometimes in “wrong” ways. Another topic the chapter discusses is the community involved in the Research through Design (RtD) project. It introduces the design and research communities, which have challenged, inspired and supported the development of this work. The chapter also discusses the larger society as an external reviewer of the work; that is, through independent people commenting on and reacting to the work from their own perspective.

PROCESS OF DEVELOPING CRAFT 3.1 AND SUSTAINABILITY QUALITIES

Fabrics and craft skills have revolutionised the world before. Under colonial rule, India exported all its cotton at a nominal rate to England. There it was manufactured into cloth in Lancashire factories and sold back to the poor in India at many times the price they had been paid for growing it. Towards the end of this period, Gandhi wanted all Indians, rich and poor, to learn the age-old craft of hand spinning so that the people of the 700,000 impoverished villages of India could regain self-employment, self-reliance and self-respect. He inspired and asked all Indians to wear the rough white cloth called “khadi” and boycott foreign cloth. Khadi became the symbol of independence in India (Easwaran, 2011, p. 101).

Not only have textile crafts shaped societies and politics throughout history, they are also known as the driver and essential element in developing current technologies and economy. “The origins of chemistry lie in the colouring and finishing of cloth. The textile business funded the Italian Renaissance and the Mughal Empire; it left us double-entry bookkeeping and letters of credit, Michelangelo’s David and the Taj Mahal. As much as spices or gold, the quest for fabrics and dyestuffs drew sailors across strange seas. In ways both subtle and obvious, textiles made our world” (Postrel, 2015).

The connection between textile and technology is even more literal. As Postrel (2015) describes, weaving was the original binary system. She claims it to be at least 9,000 years old. Warp threads are held in tension, and weft threads go over or under them: “Over-under, up-down, on-off, one-zero”. Punch cards control looms because weaving is intrinsically binary. “By the time Joseph Marie Jacquard’s card-driven machine came around in 1801, human weavers had been imagining and recording complex either-or patterns for thousands of years” (Postrel, 2015). No wonder it feels natural and beneficial to merge contemporary technology with traditional textile.

To start an experimental project, I took smart textiles as the context to apply hands-on knowledge of crafts to find directions, limitations and vocabulary for the still developing field.

3.1.1 RESEARCH THROUGH DESIGN APPROACH

The RtD approach allowed me to follow a process in which scientific knowledge is generated through, and fed back in, consequent cycles of designing and building (Frayling, 1993) and where the hypothesis-making is connected to experimentation (Bang, Krogh, Ludvigsen, & Markussen, 2012). In addition, the two feedback loops with a community of craft and sustainability experts allowed me to gain a deeper understanding and bring the insights back to the design process to refine them even further. A step into the past – the crafting approach, enabled the steps in new directions for smart textile services.

The current chapter presents the RtD elements building up the iterative model, where I designed and reflected, and brought the results to the community and back into the design process. The RtD process moved from the material to myself as the designer-researcher, towards the community around and to the outside world. The first explorations and evaluations took place between the material and myself as the designer-researcher. The results were then discussed with the community of researchers, designers, craft and sustainability experts. Beyond the community the work was also shown in public exhibitions and presentations, where the audience could give feedback and ideas. The public audience itself spread the work via blogs, magazines, newspapers, websites, and social media platforms.

The process model (Figure 41) shows layers moving outward from the material to the maker to the community to the larger society (inside to outside). The representation is based on the craft qualities described by Bardzell et al. (2012). They identified three framings of craft quality: a social-material framing of pleasure in engagement with materials, a creative-expressionist framing of linking innovation to personal identity, and a public framing linking skilled use of community resources to community aesthetic sensibilities. The process illustrations in the doctoral thesis of Nimkulrat (2009), where she describes the various phases of research as an evolving process, have also influenced the way the material, personal, community and social layers are separated. This view will be the basis to describe the RtD approach through the lenses of the material, myself, community, and society later in this chapter.

The first-person insights (Hummels & Lévy, 2013) were brought into the design process from myself and my interactions with the material. Through that, I explored the design space, reflected on the created prototypes, and opened up questions arising from them. I translated my understanding of the craft and sustainability qualities into prototypes and communicated it to the community and larger society. From the interviews with craft and sustainability experts I gained external expert opinions about my prototypes and what they communicated.

The RtD process was documented by the following means: notes, diagram drawing, sketching, interviewing, photographing, voice recording, video capture. While working with the material, sketching helped me to envision a goal and to communicate ideas. Diagram drawing and interviewing helped me to gain deeper insights into craft and sustainability qualities. The notes were used to capture the information most relevant to shaping my new understanding of the craft and sustainability qualities and to analyse it after the interviews. Voice recording was used to ensure that any important details would not be missed. Photography and video capture were used primarily for communicating the design projects and their development process. Therefore, the

data in hand includes texts, diagrams, sketches, photographs, designs in exhibitions, interview records, recordings of interviews, videos of prototypes and the making process.

BACKGROUND OF ME AS THE DESIGNER-RESEARCHER 3.1.2

Design-driven innovation (Verganti, 2009) departs from the innovator's culture, as opposed to user-driven innovation which departs from user/market studies and technology-driven innovation which departs from technological inventions (Baha, Groenewoud, & van Mensvoort, 2014). The background of the designer-researcher had an influential role to play in the interpretation of the conducted interviews, sketching and developing the craft and sustainability qualities, as well as going through the whole design process (Mäkelä, 2006, p. 70). Therefore, a little understanding of where I as the designer-researcher come from is necessary.

I grew up in Estonia – a country rich with traditional garments and knowledge of making them. From my mother and from school handicraft lessons, I learned basic textile techniques such as sewing, knitting, crochet, and embroidery. Passing it on to future generations preserves some of the implicit knowledge of crafts but a lot of insights and meanings disappear with older generations.

Of all the crafts I briefly learnt at school, my passion was sewing. I sewed new outfits for my dolls, myself and fashion shows when possible. I grew up in my parents' sewing factory which grew into a company of 50 people. I went to study Informatics at Tallinn University of Technology for my Bachelor's degree, graduated and started working as an analyst and project manager in a software development company. Next to developing Information Systems for clients in Tallinn, I entered a Masters program in Fashion Design at the Estonian Academy of Arts (EAA). The course brought me to an internship in a garment production company in Jaipur, India and a year of exchange studies at the University of Sao Paulo in Brazil. By the time I graduated from EAA with a collection of conceptual interactive scarves, which were made out of recycled knitted materials, I had been confirmed to start researching smart textile services at the Eindhoven University of Technology in the Netherlands. That gave me the opportunity to look deeper into the intersection of textiles, technology, sustainability, and crafts within the CRISP STS project.

BETWEEN THE MATERIAL AND THE WORLD 3.2

The iterative craft-inspired RtD process created a conversation and an exchange between the material and me as the designer-researcher. The resulting designs and proposals for services engaged with the community (researchers, craft and sustainability experts, project partners) by means of informal interviews, workshops, conferences and meetings, as well as with the general public by means of publications, presentations and exhibitions. On a more public note, the communication throughout the process invited external parties, such as journalists and bloggers, to publish and share information regarding the results of the research.

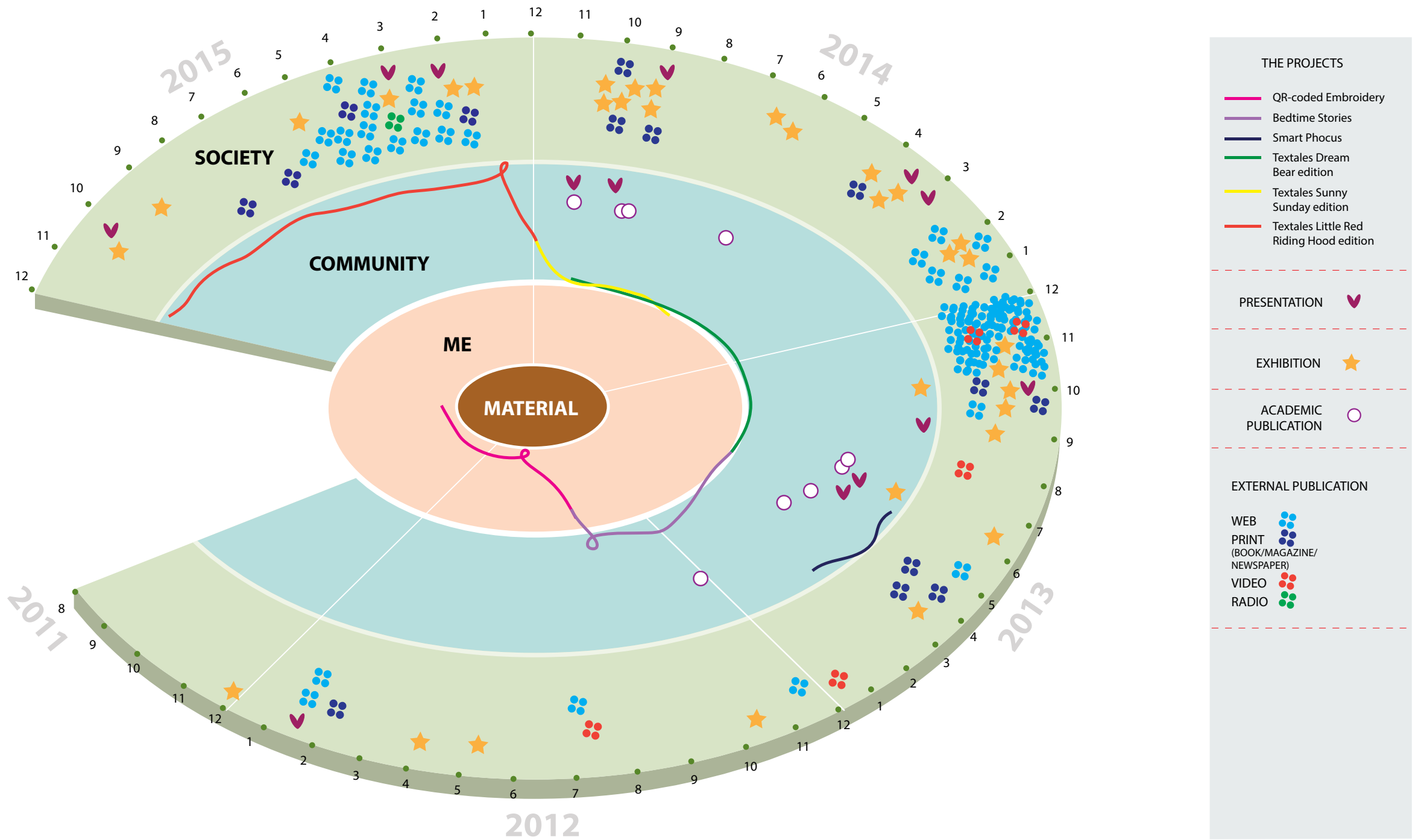


Figure 41 RtD process through material, myself, community and society. The process of developing Digital Stories on Textile (2.1) project.

The RtD process involved interaction between the material, as my cultural background mixed with smart textiles and crafts, and myself (Figure 41). Both informed each other and resulted in tangible representatives of the intangible values built through personal history. The community around, consisting of designers and researchers participating in closed events and conferences, challenged and nurtured the projects as well as the research outcomes continuously. The results were also presented to the broader society outside of the immediate community through exhibitions and public presentations.

3.2.1 MATERIAL

Material as the starting point of this research, guided the RtD process by giving inspiration and providing limitations. As discussed by Koskinen et al. (2011, p. 44) based on Branzi, design projects are moving away from being intended to alter reality and pushing it in the direction of order and logic. Instead, the projects aim to create something that can be added on to existing reality, increasing its depth and multiplying the number of choices available. In that case, the traditional way of doing research ought to be replaced with methods more suitable for design research today. Koskinen et al. (2011) show an example of the MIT Media Lab illustrating three points; first, how designers can create new worlds by doing; second, how design research needs design; and third, how technological research comes before writing. They point to Nicolas Negroponte, the co-founder of the MIT Media Lab, who replaced the academic adage “publish or perish” with “demo or die” (Koskinen et al., 2011, p. 26).

Hummels and Lévy (2013) point out that RtD process has two axes: vertically, designers using two drivers for information gathering: envisioning personal, social and societal transformation, and exploring and validating design decisions in an everyday context with citizens; and horizontally, designers using two strategies to generate information to direct and support these design decisions: design making and design thinking.

In Constructive Design Research, the product, system or media is supposed to take centre place and become the primary means in constructing knowledge (Koskinen et al., 2011, p. 5). Constructive Design Research “allows for designers to produce knowledge based on the skills and capacities of the design field itself” (Bang et al., 2012). Wensveen and Matthews (2014) refer to design research as the discipline “that aims to produce knowledge concerning design, often addresses research questions that cannot be answered without doing some kind of design activity” (p.262). They distinguish three roles for prototypes (test of specific hypothesis, open-ended exploration, illustration or demonstration) and one for prototyping (driver for the research direction), and clearly clarify the differences between prototypes for design research and prototypes for design.

My prototypes in that light served as inquiries into craft qualities. They were used first in explorative ways to identify craft and sustainability qualities in smart textile services, and afterwards to illustrate and to validate the existence of the qualities in the re-designs.

According to Brandt and Binder (2007), “a designerly engagement becomes a relevant vehicle for the production of knowledge” in design research. Therefore, they introduce programs as “an important intermediary between research question and empirical exploration” (p. 2). Through making the prototypes and presenting them to expert communities, my knowledge gained deeper iteration each time. During my research process, the intuitive, or tacit, knowledge became essential. The tacit knowledge is experiential and subjective, and it takes form through action,

becoming visible and detectable through visual expression. It can be seen as a way to grasp the world to understand it (Staff, 2012).

Talking about exemplary design research, Binder and Redström (2006) mention how “With the notion of “exemplary design research driven by programs, experiments and interventions,” we refer to research based on the explicit formulation of design programs that act as a frame and foundation for carrying out a series of design experiments and interventions.” They call it “exemplary in the sense that it enables critical dissemination through examples of what could be done and how, e.g., examples that both express possibilities of the design program as well as more general suggestions about a (change to) design practise” (p. 3). According to Binder and Redström (2006), “The program acts as a lens through which certain things will become enlarged and thus better seen, but where others will become hidden.” In my quest for identifying the craft and sustainability qualities, the smart textiles have acted as a program allowing me to see certain qualities in the experiments and hiding others.

When talking about the user in experience-centred design, Wright and McCarthy (2008) point out how people are continuously engaged and making sense experiences in the light of their history of meanings. They explain how it puts the value to what makes life personal, rich and meaningful. They point out the peculiarity of autobiographical design, where designers use their experience as a means to gain access to a rich interior world of felt life. Ferns and Hengeveld (2013) distinguish between “making for exploration” and “making for validation”, where “making for exploration” has two facets for them: “making for inspiration” and “making for elaboration”. To make for inspiration, Ferns and Hengeveld associate with ideation and conceptualization, to gain a certain overview. To make for exploration, they characterise “a search for detail in (aspects of) form and (interactive) behaviour” in high definition. My process started with making for inspiration, to find directions and ways to connect textiles with technology. It was followed by making for elaboration to find a way to develop those directions into more detailed examples of smart textile proposals. Making for validation came after identifying the first version of craft and sustainability qualities, to concretize and exemplify the found values in smart textile services context.

Biggs (2004) refers to three types of experiential knowledge: explicit, tacit and ineffable. Whereas explicit content is expressed linguistically, tacit knowledge has an experiential component which cannot be efficiently expressed linguistically, and ineffable content which cannot be expressed linguistically, he says. As noted by Apple’s head designer Jonathan Ive:

“We’d made plastic Power Books and we wanted to make metal ones for obvious reasons, because we could make them thinner and lighter and stronger. The forms that you could develop – it wasn’t just there’s a certain form in this material you could get away with – depending on the metal, certain metals when you bend them they bend in a very, very particular way. I don’t think you can be told, OK that does this, you need to do it yourself and really understand that. So hopefully the final product seems inevitable and just seems calm, because when you’ve done it right, there is a wonderful connection between the big idea, the form, the material and how you transformed the material into the final shape” (Winston, 2014).

Material as a mixture of technology, textile, culture and personal history

Sennett (2008, p. 120) describes how the craftsman in each person depends on the curiosity about the material in hand. He points out people becoming particularly interested in the things they can change, and describes three key issues people put thought into. He defines metamor-

phosis as a change of procedure, presence as leaving a maker's mark, and anthropomorphisation as imputing human qualities to a raw material. In the current dissertation, the material is a combination of technology, textile, culture and personal history. I transformed the material into experiences through which the meaning was transferred. Craft techniques provided me a better understanding from the technology and textile as the physical part of the material. The personal and cultural meaning was used as the intangible material to link my individual story to smart textile services development. Rituals give insights into important transformative transitions of life. For example, there are particular culturally dependent symbols and garments people wear for weddings, funerals and other important festivals that transform people's lives.

Personal reflection on the material

I set out to design products and services using smart textile materials. In the design process, however, I discovered that to achieve what I had envisioned, I had first to create the materials. The materials with desired characteristics and properties simply did not exist or were not within my reach. I also started to see the materials at various abstraction levels and work with prototypes having some of the envisioned characteristics present, and some imagined.

In the search for a material that would be able to change in time, I found the combination of Augmented Reality and digital stories on textiles. The *Textales* series of projects (2.1.3) can change the story they tell when desired, and communicate traditional fairy tales in modern language and context. The material that would be able to sense the human body and react with lighting, vibration and warming was found in the combination of electronic components and knitting in the *Body Sensing and Actuating Networks* projects (2.2). I developed in *Thermocraft* (2.3) meditative materials that would invite close attention with their subtle visual interaction. Once the material was developed in the context of one prototype, it opened up other options for use of the smart textile material.

On the one hand, it is very challenging to develop materials with new behaviours alone as well as in multi-disciplinary teams. My background and skill-set influenced the process strongly. I learnt how to be more open and willing to deal with unknown variables, materials and technologies. The limitations of know-how, material and machine skills can frustrate the process when I am unable to perfectly realise (or not at all) what has been envisioned. However, it also creates freedom to craft with unknown materials and tools, and to work with them in a "wrong" way – differently than how professionals use them and what they have been designed for. Also, when finding and choosing the people to work with and team up with, the skill-set expands but always remains to some extent limited. Similar constraints and freedom to find "happy accidents" remains. When people work outside of their expertise and comfort zone, they gain some sort of freedom to make mistakes. The material gains a meaning through the hands of a maker (Me) (Nimkulrat, 2009). Therefore, next I will explain about myself as the maker and designer-researcher. I describe how I translate the meaning from my culture and personal history through textiles and technology to the community and society.

My background played an important role in the RtD process. The intuitive, or tacit, knowledge became essential for the research process. Tacit knowledge, being experiential and subjective, took form through action, becoming visible and detectable through visual expression. According to Staff (2012) this knowledge can be seen as a way to grasp the world in order to understand it. This is confirmed by Mäkelä (2006), who notes that certain previously learned skills and actions relate to the prior understanding of an artist doing research. Trotto (2011) explores the act of making as a driver for giving value to human rights.

While a third-person point of view in designing implies designing for society in general, the second-person point of view implies designing with a group of people who are part of society, and a first-person point of view implies designing for yourself within the society and proposed system (Tomico, Winthagen, & van Heist, 2012). According to Tomico et al., the first-person approach is about "being the system" needed for the design vision to be implemented. Hummels and Levy (2013) describe the first-person perspective in designing as "the act of designing being about localising (making a matter concrete), questioning (reflecting on its quality), and opening up (extending sense). It is about dealing with ambiguity and resistance. About the (non)-need of preciseness, about the (non)-need of clarification, and about claiming the value of beauty" (p. 48). My RtD process started with me allowing my background to manipulate the smart textile material. Without a clear vision, working with the material itself inspired me. When the material started to form certain ideas in the context of smart textile services, the results concretised, and I presented them to the community of researchers and industry partners in the CRSIP STS project. Within the CRISP STS project, both textile and technology industry partners chose the projects to participate in and formed the work through their knowledge and vision. I, as a designer-researcher being in between the two areas, acted largely as a bridge, supporting the mutual understanding of the project partners to create synergy between the two very different sides.

Merging different disciplines is challenging. It requires determined multidisciplinary teams and a willingness to listen and to understand the teammates. During the *Wearable Futures Conference in Hybrid Culture in the Design and Development of Soft Technology*, Chang (2005) stated that the engineers are from Mars and the fashion designers are from Venus. Describing the lack of integration between design and engineering, he added: "Items are being developed and produced independently of one another and suffering from a lack of synergy of two very creative sources" (p. 4). He pointed out that "fashion is driven by looks and trends while electronics is driven by functionality" (p. 7), and explaining how fashion tends to be evolution rather than revolution, he stated, "What really influences fashion is a gradual design change that consumers can grow comfortable wearing... In engineering, it may be all about function of the product; but in fashion design, it's all about the person, how it flatters his or her personality and figure, and how the product makes its wearer feel physically and psychologically" (pp. 11-12). Applying and valuing both approaches suggests an alternative process for both industries while combining it into a joint smart textiles way of working.

Hummels and Levy (2013) describe design "being about opening up, exploring new territories, and reframing and imagining things that do not yet exist" (p. 45). They also describe design being about "surfing the waves of complexity, of uncertainty, of open-handedness, and of resistance, and about finding new worlds by engaging in the situation" (p. 45). Similarly, working with the material consisting of textile, technology, culture and my personal history throughout a RtD process, I translated the meaning found in the engagement with the material into smart textile services. My background and skills formed the process; however, the process formed me

as well. “Transducer and transformed, not only can I not cleave the entanglements between myself as subject and researcher, I am no longer the same person who began this study” (Williams, 2015, p. 127). Wakkary (2005) argues design to be an activity that responds to situations of varying complexity while being integrally related to complex yet everyday situations. He describes the design process as “a dynamic process that is improvisational and responsive to the changing design situation” (p. 67). He refers to a professional as a reflective practitioner, a term given by Schön. “A reflective professional embodies the full scope of the complexity of the design situation” (Wakkary, 2005, p. 67).

In the new wave of craftsmanship, with modern technologies, everything – the tools, the techniques and the way to look at a community – can be reconsidered. It gives great emphasis to the attitude of making things, and reevaluation of the time and attention invested in creating more value using fewer resources. It involves new ways of making things, such as rapid prototyping. The design process draws inspiration from traditional crafts and uses them to build further on the ever-changing contemporary tradition for smart textiles.

The design process compares to crafting itself. When talking about the two methods that women of the traditional communities use in their handicraft, Summatavet (2005) points out how the artifact is born in the course of its making and the existing example serves only as a source of inspiration. She shows how the details change but nature and the traditional composition logic of the object are preserved. Similarly, the process of developing this project built gradually on material, skill, technique and intuition – much like the craftsmanship approach. Each iteration had a particular goal. The physical and conceptual results were presented to audiences in exhibition and presentation scenes – in both academic and design contexts. The knowledge and feedback gained from potential users, fellow designers and industry representatives was carried into the next design iterations. The input, feedback and constraints gathered along the way adjusted the research direction. Short iterations were beneficial to establish limitations and borders to the otherwise open questions and prototypes. The frequent feedback loops from people outside of the project provided insightful information that influenced decisions taken along the way.

I as the translator of the material

Being a designer on the one hand and a researcher on the other hand, the task of choosing the “right” material to connect with (Nimkulrat, 2009) was not trivial. I was filled with curiosity and energy to explore and try out (conceptually and physically) different combinations of textiles and technology as materials and stepped into diverse directions; for example, needle and wet felting electronics into wool, sewing and embroidering with/on conductive materials, hand and machine knitting with electronic threads, crocheting with thermosensitive and conductive materials, silk screen printing and embroidering QR codes, crocheting and hand knitting electric wires into capacitive sensors and much more. Some explorations turned out more rewarding than others, and guided the direction of the following tryouts accordingly. It felt as if while I was working with the material, the material was also building, guiding and teaching me. “It seemed that in the creative process, I was simultaneously touching and being touched by the material” (Nimkulrat, 2009, p. 111).

The cultures I have lived in and my personal experiences within those cultures have formed me. In principle, I carry my culture, which has influences from different communities combined with my unique way of seeing them. I, as a person, certainly carry some of the cultural meaning from my home country, Estonia. I use the physical material of textile and technology to translate cultural and personal histories to the community and the society. The design projects aimed to

make the (cultural) material experienceable. In the RtD process I took an example from Estonian culture and re-mapped some of the meanings in the form of craft qualities. I explored the concept of crafts with its inherent meanings to find out how to embed it into other areas, such as smart textile services. There is a fine balance in crafts – how much of the meaning can be revealed from implicit to explicit. How much of the meaning that is hidden in the original culture can be revealed (Schiphorst, personal communication) through smart textile services?

Coming from a combined background of information technology and fashion design, I could use the tools of both domains in their “proper” use as they are meant to be used as well as exchanged, e.g., crocheting coated electric wire (Figure 42) and discovering its capacitive sensing properties, or embroidering QR-codes on a fabric and discovering its storytelling properties (Figure 42). Or as Sennett (2008) puts it, “a tool initially used for one purpose can be applied to another task, and how the principle guiding one practise can be applied to quite another activity” (p. 127). Similarly, Professor Emeritus of Aalto University School of Arts, Design and Architecture in Finland Juhani Pallasmaa stated during a keynote presentation at the Art of Research 2014 conference that no tool is innocent. Every tool permits and limits other things. He recommended using different tools in different tasks. He spoke about hands being standard and very unique at the same time, hands having stories (Pallasmaa, 2014).

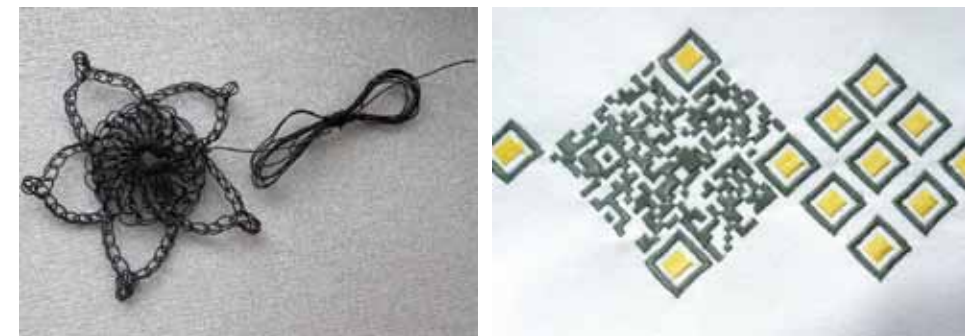


Figure 42 Left: Electric wire crocheted into a flower shape that turned out to react as a capacitive sensor. Right: QR code, which is embroidered on a textile and can be scanned with any smartphone, therefore allowing the textile to carry digital information.

Weaving various disciplines and knowledge through a common goal was a leading line throughout the project. At a certain stage, my own skills and know-how were augmented by the surrounding community, which shared feedback, knowledge and their facilities to bring the prototypes further.

Personal reflection on working with the material

The process of the RtD project started with exploring and discovering, learning what works and what does not, how the environment (places, machines and people) supports and constrain the work. As in any exploration, there were cultural discoveries side by side with personal ones. It was impossible to predict or anticipate the joy and frustration of working with a new machine, trying to make it do what I envisioned, and in the end surrendering and accepting my own and the machine’s limits.

I spent nights and weekends in the empty cold silent light (or dark in the winter) space in the

Wearable Senses space in the old main building of the university. I was looking for something – maybe a result, perhaps progress, maybe myself in the new and unknown environment that suddenly had become “home”. The embroidery machine that I had taken up for challenge (being the only machine in the lab that I did not have any experience with) ran smoothly during many tasks, depending on the material and settings. However, it also created headache and disappointment showing its limits, “opinions” and “character”. I had a great struggle balancing between the possibilities and the limitations of the machine. Being stubborn and determined, it took quite a while before I was able to give up and give in, to feel the machine and follow the inspiration it was providing me.

To start with the explorations of working with smart textiles, my first attempt was to embed electronics into soft traditional textile materials. Since LEDs and smaller motors were familiar to me, I started to combine them with hand knitting, crocheting (dry and wet), and felting; techniques also known to me. The results were somewhat flashy, expressive and attractive but rather complicated to use. It felt unnatural to force two very different components, techniques, areas and worlds together. It showed problems that would only increasingly expand: care taking, reliability, resistance, battery consumption, disposal and so forth.

After what seemed unnatural – embedding electronics into textile structures, I started to look into alternative ways of bringing textiles and technology together. I wanted to find out whether there was a way to bring digital interaction into textile without attaching the physical hard electronic components into textile structures. After brainstorming some ideas, I started to experiment with the simplest ones, the ones I could try out quickly myself. I embroidered a QR-code and found out it worked! The “beginner’s luck” was followed by many failed attempts to modify different QR-codes, and finding the limits for both the code and the embroidery. There was a very fine line where the QR-code was visually pleasing and also functioning well. The extended tryout sessions led to finding parallels between traditional embroidery and digital technology, such as QR-codes. The way that both carry old (static) and new (dynamic) layers of information in them motivated me to create some examples as sustainable smart textile services cases. However, working on such items also made me wonder whether people would like to be scanned by smartphones if they would wear some of those QR-code textiles. Would they like to be looked at, so explicitly, through a screen? On second thought, I realised that people are scanned and looked at in our society in any case. The difference was that with a QR-code people could choose what kind of information they would like to carry on them.

Bringing QR-codes and later Augmented Reality as an external layer to the surface of textile was interesting but made me also think about how to avoid the extra screen. How could I bring the “story” and the dynamic property itself to the textile? I started to look into thermosensitive textiles. I was trying to find yarn or thread that would react to the ambient temperature. However, this turned out to be a challenge and motivated me to develop the yarns that would sense people’s activity and respond by revealing multiple colours.

The meaning and value of a work can be found when confronting the outcome with the surrounding community. Knowledgeable and critical, the people working in similar areas can help reasoning and understanding develop much faster and more creatively. Letting the community into “the workshop” while the designs and ideas are still works-in-progress, allows its feedback and ideas to be used while steering the process, and not only evaluated once it is finished. In this case, community consisted of designers and researchers who have interacted with my work in closed events, workshops, personal meetings and conferences.

Focus of the study

The focus of the study was to identify craft and sustainability qualities in the smart textiles services context. I chose experts in particular fields as participants to shed light on the topic. The data were gathered through alternating the understanding about the study focus, of myself as the designer-researcher and through the input and feedback from the expert reviews.

This study borrows methods from grounded theory (Glaser & Strauss, 1967), which emphasises discovery and theory development over the logical deductive reasoning which relies on prior theoretical frameworks (Charmaz, 2011). According to Charmaz, grounded theory has the following fundamental methods. First, he points out that the data collection and analysis happens simultaneously. The data collection is shaped by the analytic interpretations and discoveries of the researcher. Second, he stresses that both the process and products of research are shaped from the data. Third, the researchers following grounded theory methods need to check their developing ideas with further specific observations. They make systematic comparisons between observations, and, often take their research beyond the confines of one topic, setting, or issue. Fourth, according to Charmaz, grounded theorists not only study process, they assume that making theoretical sense of social life is itself a process.

Following the hermeneutic circle fundamental principles for interpretive field research of Klein & Myers (1999), I iterated between myself as the designer-researcher and experts in environmental, societal and economic sustainability to find the shared meanings and emerging themes from the environmental, societal and economic sustainability. I specifically used the multiple interpretations principle of Klein & Myers (1999) to find out how the environmental, societal and economic layers related to each other within the three described projects. As Klein & Myers state, “The principle of multiple interpretations requires the researcher to examine the influences that the social context has upon the actions under study by seeking out and documenting multiple view-points along with the reasons for them” (p. 77). “Moreover the researcher should confront the contradictions potentially inherent in the multiple viewpoints with each other, and revise his or her understanding accordingly” (p. 77).

During the research process I conducted informal interviews at participants’ work places (e.g., Estonian Academy of Arts in the Fashion Design department, Aalto University in Arabia and Töölöö campuses, Delft University of Technology in the Industrial Design department), in between “Sustainable and innovative fashion seminar” sessions at Aalto University, in public cafes in Tallinn and over e-mail exchanges. I developed the insights from the interviews into craft and sustainability qualities, applied them to the re-design of Digital Stories on Textile and asked the experts for further reviews to gain a deeper understanding of the craft and sustainability insights.

The experts were interviewed instead of end users, because I expected experts to be better able

to analyze the prototypes. They were believed to see the values and connections between the prototype and their fields of expertise. Since the prototypes were envisioned for products and services that ought to change the behavior of the future users, the world (nor the user) they were designed for, did not exist yet.

As in any qualitative research context, the content could be understood in many ways and the interpretation is subjective (Graneheim & Lundman, 2004). I read the notes from the interviews through several times to understand the underlying meaning of what was said, and then compiled them into an overview table to make sense of the bigger picture. I divided the observations from the interviews into separate qualities, represented by quotations, and developed them into condensed meaning units, interpretation of the underlying meaning and gave titles according to the method described by Graneheim and Lundman (2004). They explicitly point out that the text always involves multiple meanings and the researcher's interpretation is influenced by their personal history. They say that in qualitative content analysis, interpretation requires a balancing act between the researcher adding a particular perspective to the question under study, but not imputing meaning that is not there.

Community as the critic and the motivator

The surrounding community persistently challenged and refined my individual motives and understanding of the craft and sustainability qualities in smart textile services throughout the RtD process. The prototypes as the carriers of knowledge were confronted along the way by the researchers, craft and sustainability experts and designers.

To achieve producible smart textile products, I presented the created ideas and prototypes to CISP STS industry partners. The community of textile and technology partners, formed into multidisciplinary teams, contributed to the projects with their expertise. Working in interest-based self-motivated teams brought out the craftsmanship side in each team member. According to Sennett, "The craftsman in each of us represents the desire to do something well, concretely, for its own sake" (2008, p. 144). That created synergy within the teams to improve and motivate each other to do better to achieve a common goal.

To find out how craft and sustainability qualities could inspire the development of smart textile services, I surrounded myself with a community of craft and sustainability experts. I brought my initial understanding of the example projects to the community, and refined it into the redefined understanding of the craft and sustainability qualities. After another design iteration, I brought the redefined understanding back to the communities of craft and sustainability experts, and reflected with them how the qualities appear in the final design.

Thanks to the know-how and facilities of both the technology and textile partners, the projects were up to the standards of both industries. Therefore, they could be shown at exhibition venues and presentation settings. The research results were introduced to people inside and outside of the academic context to receive their feedback.

Personal reflection on the community

Developing the sustainable smart textile services inspired by craft qualities has been a craft process in itself. The constant sharing of knowledge, information and ideas to achieve common goals has contributed to a self-sustaining community of collaboration partners.

From the design point of view, there was a recognisable transfer moment, when the QR-coded Embroidery (2.1.1), that I had developed from my cultural background, carrying local values about time, details, fairy-tales, family and sustainable living, became a collaborative project, Bedtime Stories (2.1.2), incorporating values added by the team members. The additional aspects brought in by the industry partners were, for example, a new weaving technique, Augmented Reality technology, and vision for commercial opportunities. The Bedtime Stories prototype was developed to validate the concept of storytelling through image recognition and human interaction with textile. It served as a tool to create a common language between industry partners, academic and creative parties (Bhömer, Tomico, Kleinsmann, Kuusk, & Wensveen, 2012). From the research point of view, I was building a community with which to discuss the craft and sustainability qualities in smart textile services.

SOCIETY 3.2.4

While the community was closer to "Me", the communication was easier. There was a lot of shared understanding between myself and the community I worked in. However, communicating with people outside of that community was different. They "mirrored" a different layer of the work by looking at it through their diverse backgrounds. Through them I could learn what was the core message of the research that got through from the material to the world. And by listening to their reflections, I could change the message, to refine it over time.

Society as a mirror

Bardzell et al. (2012) talk about public framing that links skilled use of community resources to community aesthetic sensibilities. The community of researchers, artist, designers and engineers working in the smart textile area is limited but very supportive. Many people involved in the e-textiles field know the work of other smart textile projects. Group exhibitions are very common and provide a bridge from academic context and research to the public, to the world. Nimkulrat (2009) takes craft-based art to other people, practitioners, educators and researchers through several exhibitions, placing the paper string objects into a white gallery space. Society outside of the community of researchers, designers and project partners reflects back what has been communicated to outside.



Figure 43 Vibe-ing and Bedtime Stories as part of ArchInTex exhibition in Ronse and Bedtime Stories shown during the Nerds on Stage event in Rotterdam.

Exhibitions create interesting connections through the work, between me as the designer-researcher and people from different disciplines. The current work has been shown at more than


55 events in Europe, North America, Asia and Oceania; for example, the annual Dutch Design Week in the project's home town Eindhoven, museums in Breda, Vienna, Ghent, Zürich, Horst, Leiden, Wuxi, Saskatoon and other places (Figure 43). A selection of the presentations and exhibitions can be found in the Appendices 1 and 2. Additionally, the project descriptions, photos, videos and publications have been shared online. "An exhibition offers the artist an opportunity to test whether her expression has come across clearly enough" (Nimkulrat, 2009, p. 208). It also allows the developers to understand what matters to people, what kind of meaning they give to it and what potentials they see.

The exhibitions, presentations and communication materials coming from myself carry my view of the project and the meaning it ought to carry. The reactions, comments and posts by external people sharing their opinions about the work they have seen, is entirely independent of my perspective and background. Observing other people describing the design work in social media, blogs, newspapers, magazines and broadcasts, from their perspective in their context, on their motivation, allowed me to notice new angles to it. The external communication validated whether the communication from my side had been clear. For example, I only realised the unique positioning of Tender (2.2.2) within other wearable technology examples when Weir (2012) wrote on the Crunch Wear website that "The world of high-fashion is home to many kinds of unique wearable technologies, but one thing the fashionistas usually have in common is an aversion to touch. After all, the garments are usually one-of-a-kind and were placed on the gaunt model via a combination of safety pins and a lot of luck. In short, if you break it you buy it. So it comes as quite a relief to see one tech-heavy garment coming down the pike that not only encourages touch, it actually requires it". The comment showed the more interesting and valued aspects of the prototype. It gave an idea what people miss in fashion technology, what they like about our work and which aspects need more clarification to be understood in the wider society.

Personal reflection about the feedback form the society

The comments and questions received from exhibition visitors were insightful throughout the process. For example, several visitors mentioned doubt about bringing the iPad to bed and bedtime stories. However they also noticed such a concept as an opportunity to bring fathers closer to storytelling and their children. Visitors suggested that the concept could encourage families to share more stories and pass on experiences. A very interesting question posed by one of the exhibition visitors – "Would the storytelling behavior stay with the family after removing the technology?" – certainly deserves further investigation. People commented that it was a nice project to persuade children to go to bed. Their reactions informed the RtD process and created an exchange of meaning, from the material through myself and the community to the world and back.



 Scan the image with the Textales LRRH app!

CHAPTER

4

Based on the intuitive relation between crafts and sustainability as described in the introduction (Chapter 1), I take crafts and craftsmanship as a starting point to explore how smart textile services (Chapter 2) could implement ancient craft knowledge. Through the RtD process (Chapter 3), which included a round of interviews with craft experts, it turns out that traditional crafts and the smart textile examples QR-coded Embroidery (2.1.1) and Bedtime Stories (2.1.2) share nine craft qualities: Embedded Meaning, Material as a Medium, Hidden Stories, Heritage and Tradition, Touch and Feel, Societal Responsibility, Family Connection, Open Source Community and Evolution in Time. This chapter shares insights into identifying the craft qualities, how they influence the redesign of Bedtime Stories into Textales (2.1.3), and reflections about how the craft qualities appear in the final design. The insights can be used for the future development of craft-inspired smart textile services.

BACKGROUND OF THE TRADITIONAL CRAFTS 4.1

TACIT MEANING IN CRAFTS 4.1.1

Crafts, with the traditions and rituals surrounding them, have lasted for millennia. The first evidence of sewing needles dates back to around 30 000 years, which proves crafts to be a sustainable practise. The insights into sustainability from those years of practise should be noticed. Handwork used to play an important role in the production chain. Specialised craftsmen had the textile processes embedded into their hand lines. Every bundle of crops was picked and treated by skilled hands. Each stitch, loop, and cut had its order when to be made, and the way they were made had developed from boundaries and reasons set by the environment, materials and the item's purpose (Gordon, 2010).

The main reason to look back and take inspiration from strongly built traditional textile crafts for developing smart textile services is the tacit meaning hidden in the material and the making; making and using – the sense of transparency throughout the item's full life cycle. It is not merely a technological approach, but an attempt to understand certain behaviours and values; to regain some of the long-lived principles such as quality, individualised approach (tailoring) and value for handwork that was neglected when moving towards efficiency and standardisation. These behaviors and values are proposed to be present in the design process, or in the service and use of smart textiles.

Smart textiles allow new values and ways of use to emerge in the textile industry. With their dynamic properties and collaborative approach (Bhömer et al., 2012) they call for a radical change in the garment industry. For a radical change, paradigms need to change rather than the materials we use, the way garments have been made, or how many times we use one cradle-to-grave item. "There's nothing physical or expensive or even slow about paradigm change. In a single individual it can happen in a millisecond. All it takes is a click in the mind, a new way of seeing" (Meadows, 1997, p. 11). Therefore, it is important to consider the new directions that become available with the introduction of smart materials. In this dissertation, technique is considered a cultural issue rather than a mindless procedure. Techniques are looked at as ways of conducting a particular way of life (Sennett, 2008).

Currently, smart textiles develop largely together with the technology. They depend on new materials, better ways to connect textiles and technology components, and more advanced production processes. “The electronics field still dominates product development, and consequently most research attempts focus on solving technical problems such as integrating microchip and computer systems into clothing or overcoming washability issues” (Cherenack & van Pieterse, 2012, p. 4). Baha (2013) explains how design-driven innovation departs from the innovator’s culture, as opposed to user-driven innovation departing from user/market studies and technology-driven innovation departing from technological inventions. He points out that in order to aim for a more radical instead of incremental change, a certain distance needs to be taken from the user/market and sometimes also from the integration of new or existing technology in a new market or sociocultural regime.

Some opportunities to find meaningful directions for smart textile development might be overlooked with only technology-driven approaches. Nimkulrat (2012b) points out the great depth of crafting and its qualities: “Through the skilled hands of a craft practitioner, not only form is given but also meaning is embedded” (p. 7). Sennett (2008) is very clearly saying crafts and everything related to them are much more than just old techniques. He talks about material-engagement as part of the craftsmanship approach as the basic human impulse and the “desire to do a job well for its own sake” (p. 9).

According to Nimkulrat (2012b), craft also involves direct experience, personal vision, and mastery of a medium, and thus is a form of practise applicable to any design or art process or activity. She refers to them as the objects or outputs of experience. Na (2012) defines craft as a “creative activity by humans whose aim is the aesthetic functional object, realized from its whole life cycle as finished object, practise of making process, and services” (p. 15). She also separates contemporary craft that focuses on the “presentism” of craft and contemporary living (the last ten years) and traditional craft that belongs to the past.

Sennett (2008) also links innovation to one’s personal identity, talking about craft as a more advanced level of technique, such that the “technique will be intimately linked to expression” (p. 149). Similarly, Bardzell, Rosner and Bardzell (2012) argue that craft is not a dead skill from the past to be preserved, but rather that craft participates in everyday life and evolves over time. There needs to be a certain comparison between the craftsman and the community in order for the work to develop and stand out.

Merzali Celikoglu (2013), Tharakan (2011) and Tung (2012) stress the importance of linking skilled use of community resources to community aesthetic sensibilities. Craft in essence is directly linked to a specific community and place. “Pre-industrial artisans were skilled craftspeople who used locally available materials to create products and generate income” (Tung, 2012). Craft is also highly cultural and carries an important role in documenting culture. Handicraft has been used as information storage, telling stories about the village and histories of the community. “Cultural traditions are a continuation of the past, as well as a projection into the future, actually being elements of the continuity of a society’s history. At this point, craft products can be taken as one of the transmitting elements of culture and tradition. Craftsmanship and so, craft products are material beings in the intersection of culture, tradition and society since historical production techniques and rituals generate them” (Celikoglu, 2013, p. 36). Craft objects are believed to have emotional value for the user in a meaningful way. They carry a story and an identity (Tharakan, 2011, p. 197).

By looking into crafts that have evolved over centuries, smart textiles, as a developing field, gains

an opportunity to be design-driven considering the innovators’ culture and personal history as part of the material that is manipulated by the maker and the community around her. Different ideas arise in the smart textile services context, when the maker listens to the material and allows it to shape the design process.

ESTONIAN CRAFTS & MUHU SKIRT 4.1.2

The garments we know today as folk costumes were initially festive clothing for Estonian people in different regions until the 19th century. In the 19th century the folk costume started to diminish from daily use, because people started to move to the cities. The folk costume became an important element during the Estonian Age of Awakening (Estonian: *Ärkamisaeg*) that is, a period in history where Estonians came to acknowledge themselves as a nation deserving the right to govern themselves. It was used to demonstrate nationalism during national events and the Estonian Song Festival (Estonian: *Laulupidu*). With the Soviet period, the meaning of folk costume as national symbol changed. The clothes were used as a uniform during song festivals and standardised by the *Uku* production association. Estonian awareness became even stronger during the second Russification wave in the 1970s and 1980s. Since flags were forbidden, folk costume was the only strong national element creating a sense of belonging. After the events of the Singing Revolution (a commonly used name for events between 1987 and 1991 that led to the restoration of the independence of Estonia, Latvia and Lithuania) the folk garments drifted out of attention. The interest in the folk background was strengthened once again in 2007, when a bronze soldier statue removal from Tallinn led to strong disapproval from Russia and provocations to protests in Tallinn (Puppert, 2011).

I believe there is something magical, meaningful, and sustainable about crafts and the mindset they contain. To understand more about Estonian crafts and their possible relation to smart textile services, I asked the people working with crafts and craft research to share their thoughts on it. To keep a consistent tangible reference when talking about crafts and craftsmanship, I focused on an iconic folk costume skirt originating from the Muhu Island in Estonia.

The Muhu skirt (Figure 44) is part of a representative folk costume of the third largest island in Estonia lying in the Baltic Sea. The costume originates from the beginning of the 20th century and has gone through many changes over the years. Among other changes the skirt went from single colour to stripes, from reddish brown colour to reddish and orange. Patterned stripes accompanied the usual stripes and the lower edge got decorated with a crochet lace. Since the 1930s a lemon yellow skirt with a flower-embroidered border has been iconic to the island (Puppert, 2011, p. 159). The function and properties made perfect sense. “A woolen skirt is never too hot in summer because a linen underskirt airs it. At the same time *kört* [a type of apron] protects from wind and rain – when the rain stops you just have to shake *kört* dry, because its woolen material does not soak water in” (Summatavet, 2005, p. 92). Here begins the R&D process aiming to understand how the traditional crafts could support the design of sustainable smart textile services.



Figure 44 Muhu skirt worn by Mareli Ots, photo from Mareli Ots private collection. Photo by: Dejan Patić (2012).

At the beginning of the RtD study about craft qualities (Figure 45), I, as a designer-researcher, formed my initial understanding about craft values in the context of smart textiles. That understanding was reflected in the first developed smart textile projects. I incorporated craft qualities such as embedded meanings, stories, tradition, and community support into the design of smart textile services. The understanding was broadened via semi-structured interviews with five craft experts focusing on Muhu skirt, QR-coded Embroidery (2.1.1) and Bedtime Stories (2.1.2) projects. The gathered information became the basis for revising my understanding of craft values in the smart textile services context. The first version of craft qualities was drafted according to my revised understanding and assigned with the applicability, label, and a meaning. The results were brought back to the craft experts for the review of the first version of craft qualities, in order to achieve the second version of craft qualities. The review was focused on seeking the craft qualities in the re-design of the Bedtime Stories project - Textales Dream Bear and Sunny Sunday editions. Based on my reflections on the comments received from the craft experts, the second version of craft qualities deepens and becomes more concrete.

The craft qualities interviews were collected from five craft experts, who have a background in Estonian crafts. The qualities were reviewed with three of the same craft experts.

CRAFT QUALITIES

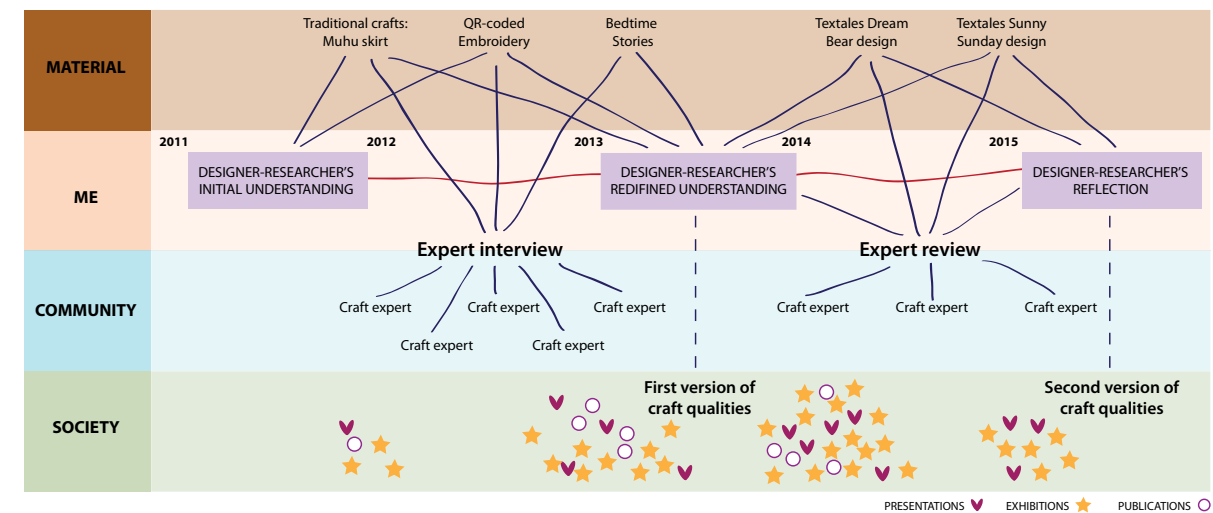


Figure 45 The RtD process in discovering and refining craft qualities in smart textile services.

4.2 CRAFT QUALITIES IN MUHU SKIRT, QR-CODED EMBROIDERY AND BEDTIME STORIES

Crafts and craftsmanship carry my personal culture and understanding through smart textile services to the outside world. This section introduces how the research data was collected from the community of craft experts and then handled. The insights into the craft qualities in traditional crafts and smart textile examples QR-coded Embroidery (2.1.1) and Bedtime Stories (2.1.2) from the craft expert interviews are shared along with my personal experience of working with the material.

4.2.1 METHODS FOR COLLECTING AND HANDLING DATA

My understanding of the craft qualities in the context of smart textiles changed from the initial understanding of myself as the designer-researcher to a redefined understanding (4.3). That improved understanding was gained through expert reviews and redesigning the project iterations. This section highlights how my initial understanding broadened via semi-structured interviews (Fylan, 2005) with five craft experts. The interviews focused on the traditional Muhu skirt, QR-coded Embroidery and Bedtime Stories projects. From the interviews it became clearer how and why the craft experts recognise craft qualities in the traditional craft as well as in the smart textile examples. The collected information became the basis of revising my initial understanding of craft qualities in a smart textile services context. The first version of craft qualities was drafted based on that redefined understanding. Later in this chapter, the craft qualities are associated with a meaning and a label for clarity.

To deepen my understanding of craft qualities, I conducted interviews with five craft experts, all knowledgeable about Estonian or Nordic crafts. The craft experts related to Estonia were selected to be able to gain deep focus on one culture, instead of broadening the view through multicultural selection of craft experts. The craft experts selected to participate in the study have various backgrounds in craft practise and research. Mirje Sims (RahvakultuuriKeskus, 2015) is the chairman of the board of the Haapsalu Handicraft Association in Estonia. Her main interest lies in Haapsalu scarf preservation and innovation. Katrin Kabun (2015) is a wool and knit expert devoted to promote traditional wool. Tuulia Lampinen (2015) is a Finnish textile designer and weaving professional who is doing her doctoral studies on the 17th-18th-century silk fabrics at the Aalto University School of Arts, Design and Architecture. She is interested in the technology that past master weavers used and how that knowledge can be applied today. Marit Ahven is a fashion design lecturer at the Estonian Academy of Arts and is also HULA project manager. Her interest is mainly in sustainable fashion. Dr Nithikul Nimkulrat is a Professor of Textile Design and Head of the Textile Design Department at the Estonian Academy of Arts in Tallinn, Estonia. She earned a Doctor of Arts from Aalto University in Finland. She interweaves creative and research practises in her work (Nimkulrat, 2015).

The experts were involved through informal conversations, semi-structured interviews and e-mail exchanges. The communication was kept open to find new directions for the conversation and to explore what the experts would like to bring into the discussion. Celikoglu (2013) points out, based on Feldman (1999) and Pink (2007), that the conversation as a cooperative venture has a direction allowing new understanding. The transmission of knowledge through an informal conversation also provides the potential transfer of tacit knowledge. The discussion

in general was kept rather open for sharing mutual interests and opinions. Additional questions were spontaneously asked. Related stories were shared also without direct questions. The interviews were analysed keeping in mind the subjectiveness of interpretations in qualitative research (Graneheim & Lundman, 2004) through my background.

The Muhu skirt, QR-coded Embroidery, and Bedtime Stories projects were introduced to the experts during the interviews. They were asked to react to the ideas in an open manner. The experts were asked to point out what they did and did not like about each project. They also reflected about the value they saw in the three examples. Each expert also pointed out the similarities between each of the items presented. Ultimately they were asked about the similarities in all of the projects. The interview questions were open ended and the conversations were allowed to take different courses depending on the interest of each individual participant. The projects were chosen so that they would form a coherent story from the initial inspiration Muhu skirt to the design prototypes. QR-coded Embroidery has a more obvious visual relation to the traditional folk skirt. However, it has technological limitations. Bedtime Stories embodies a more open and flexible approach on the technology side, however the link to Muhu skirt is more challenging to determine. The interviews lasted approximately 1 hour each and the data was captured in notes. The notes were transferred into a table (Table 1) showing the reactions of craft experts during the interview, and were later attributed with a meaning and a label representing each quality.

RESULTS FROM THE CRAFT QUALITIES INTERVIEW 4.2.2

The craft experts shared their opinion about the craft values they saw in the Muhu skirt, QR-coded Embroidery, and Bedtime Stories projects (Table 1). They also pointed out what kind of values they saw appearing similarly in all the three examples. The different topics are grouped to achieve condensed meaning units and they have been attributed with labels. The label became the title for the craft quality.

For example Nimkulrat found the value in Muhu crafts that there are many layers of meaning (row 1, column 1). Ahven noted the value of QR-coded Embroidery to be “What first seems as a modern decorative fabric with historical origins also contains a message that can only be seen by the mediation of technology” (row 1, column 2). Also, about the value in Bedtime Stories, Ahven mentioned “I like the innovative approach and layering, that attracts the modern generation to look into fairy-tale wisdom” (row1, column 3). When asked about the similar value in all three projects Nimkulrat stated that there was something more than you could see in the projects (row 1, column 4). The meaning attributed to group these previously mentioned comments together is “Ornaments and symbols” (row 1, column 5), and the label or title given to the quality is “Embedded Meaning” (row 1, column 6). In the next section the table will be introduced in detail in the context of the analysed projects.

THE VALUE OF MUHU SKIRT	THE VALUE OF QR-CODED EMBROIDERY	THE VALUE OF BEDTIME STORIES	SIMILAR IN ALL THREE	MEANING	LABEL
Many layers of meanings. (Nimkulrat)	What first seems as a modern decorative fabric with historical origins, also contains a message that can only be seen by the mediation of technology. (Ahven)	I like the innovative approach and layering that attracts the modern generation to look into fairy-tale wisdom. (Ahven)	There's something more than you can see in here. (Nimkulrat)	Ornaments and symbols.	Embedded meaning
The history woven into the patterns gets introduced to and valued by the current generation. (Ahven)	I like the novel approach, to use the technology development to re-understand the old textiles into modern language. The value is the use of old in the new way. (Sims)	Novelty and skillful connection between the textile and IT technologies. (Kabun)	Textile as a medium. (Lampinen) Creating new meaning and communication language for the future user. (Ahven)	The act of making, Material, Environment.	Material as a medium
They want to keep the story for the next generations. The handicraft has been much more before the technology. It's a way to record the important stories. (Nimkulrat) Shared story of how you make things. (Lampinen)	Favorite pillow because of the story. (Nimkulrat) The strengths are surely the approach that is understandable by youth, and the opportunity to introduce the history through modern example. (Ahven)		Story, storytelling. (Lampinen)	How things are made, worn and used.	Hidden stories
The main value of folk garments, in my opinion, is the opportunity to demonstrate your roots to others - where you come from. Also, wearing them today indicates the wearer's broader view to the world. (Sims) Traditions, connection to ancestor's culture, interesting and attractive, bright colors, energy. The main value in in the traditions and the way it values ancestor's culture (Kabun). Similarities between the different cultures? Patterns keep repeating all over the world, because patterns come from the technique. (Lampinen) Handicraft in different countries have shared patterns and everyone always compare with where they come from. (Nimkulrat)	The connection between the ancestor's culture and modern technology. (Kabun) Value is in choosing the color according to the cultural heritage. It can be carried for a lifetime and even mixed with and from different heritages. (Lampinen)	The idea that if you interact with the sheet, not just by touching it, but in a childish way... it has to show clearly on the character how they move. It could be educational material so that children know what they do with the sheet and they see the reaction immediately. (Nimkulrat) Going under fabric- textile is very close to you. <i>Touch</i> is very active (textile basic property). (Lampinen)	Connection with the person's individual past, or to put it in other way: the opportunity to create new codes for defining your origin. (Sims) Connection with the tradition lowers in each iteration. If the weaving of the Bedtime Stories would contain some traditional embroidery or similar colors with Muhu skirt, the connection would be more obvious. (Kabun)	Learning within a community.	Heritage and tradition
Touch from making the material. (Lampinen)	I like the choice of technology, that it is embroidered instead of printed. (Kabun)		Interactivity or the invitation to interact with it. (Nimkulrat) Touch. (Lampinen)	The material qualities and properties forming the outcome, pattern comes from the technique.	Touch and Feel
It also shows the preference of people especially in terms of colors, also related to the resources available in the community. Hundred years ago they needed to find the plant to paint the fabric. (Nimkulrat)		Quality textile, sustainable. (Lampinen)		Knowledge where the materials come from and about the maker.	Societal Responsibility
		To create the bond between the grownup and the child. (Sims) Connection with the "soft" values. (Kabun)		Sharing stories while making together.	Family Connection
With patterns and motives they always carry a meaning, they come from what is surrounding in their everyday life, and what is happening in the community. (Nimkulrat)		The courageous approach to fairy-tales in a modern language. The main value I believe to be in the opportunity for developing it constantly further. To create new characters, new games. (Sims) Open source community		Adaptive, changing in time.	Open Source Community
	Wide opportunity to further development. (Kabun) The good idea is that you can change the story if you want, and for some children they just need one story, the choice that you can choose to change it or not. (Nimkulrat)	Wide use-case pool - at home, hospitals, disabled kids. (Kabun) Modern approach and adaption to current generation's behavioral patterns. (Ahven) Building your own characters could be a value. (Lampinen) In terms of a product it would be good idea to have themes, like for example castle environment, space environment... and different characters that you can choose to enter the story. Many stories could be created on one theme. (Nimkulrat)		Changing and developing over time.	Evolution in Time

Table 1 Comments from craft experts about the craft values seen in the smart textile projects.

The next section presents the multiple viewpoints of the craft experts about the three objects and the meaning they carry. The expert input about craft qualities in the traditional folk garment Muhu skirt and the smart textile examples QR-coded Embroidery and Bedtime Stories is demonstrated and analysed. Some material-related qualities emerge, such as material communicating stories as a medium and touch being the essential property of a material. Time-related quality is about craft evolving in time. Several meaning-related qualities are pointed out: embedded meaning, hidden stories, and heritage and tradition. Craft qualities also include relationship-related characteristics, such as societal responsibility, family connection, and open source community.

4.2.3 CRAFT QUALITIES IN TRADITIONAL CRAFTS: MUHU SKIRT

The rich and colourful world of crafts is complex in its depth as well as the multiple layers it has for interpretation. Different patterns, loops, embroideries, accessories on garments, belts, mittens, socks, etc., carry particular meanings which a master or a craftsman has embedded in the item during the making process. To keep the conversations and ideas around crafts synchronised and focused between the craft experts and myself I chose to focus mainly on one craft item as an example – the Muhu skirt (Figure 46). The iconic bright yellow skirt stands out and carries an interesting history.

Craft qualities in Muhu skirt

For Muhu women, the act of making the textiles and beautiful personalised clothes was more than a merely practical issue. It was a matter of taking great pleasure in engaging with materials, and a way to connect to oneself and build a character. Crafts, through a constant process of making, comparing, and improving, have closely linked innovation to one's personal identity. Folkloric embroidery, traditional patterns on mittens and socks, the variations of colours on the skirt stripes – they all meant something specific for the family or village producing and wearing them. Traditionally, they used to be taught and developed within the local communities. It used to be a personal story only understood through the knowledge of the local context and an outsider could only see or hear the meaning if she was given the key to it (Summatavet, 2005).

Crafting is highly defined by locally accessible materials, and influenced by the surroundings of the community linking skilled use of community resources to community aesthetic sensibilities (S. Bardzell et al., 2012). Similarly, the Muhu skirt has its material origins explained. The bright yellow tone that is very characteristic to the Muhu skirt is sometimes also called “mine yellow”, because the Muhu women acquired the necessary yellow tone for the bright yellow skirt yarns from material washed up at the local port in 1930 from sea mines (Puppert, 2011). Sewing and other crafts have been seen as a separate language by people moving into a community whose language they do not speak. Making things with your hands bridges the language gap between people. Similarly to learning a new language, practicing a craft opens up a new cultural space for the craftsman.

The aspects pointed out by the craft experts during the interviews and additional communications about the Muhu skirt's craft qualities emphasises the long-standing representative role of the garment. It showcases the heritage, traditions, and connections to the ancestors' culture. Ahven specifically mentions the value of using the ethnographic frame of reference and bringing it into the present. According to Nimkulrat, patterns and motives always carry a meaning. They come from what is surrounding their everyday life and what is happening in the community. She also mentions that those everyday issues got into crafts because people wanted to keep the stories

for the next generations. “The handicraft has been much more before the technology. It's a way to record the important stories” (Interview with Nimkulrat, 5.12.1013). The craft objects say a lot about the surrounding resources available in the community in terms of skills and nature.



Figure 46 Muhu folk costumes, ERM EJ 415:32, Eesti Rahva Muuseum, <http://muis.ee/museaalview/729737>

CRAFT QUALITIES IN SMART TEXTILES: QR-CODED EMBROIDERY 4.2.4

Embroideries with their personal and detailed touch, allowing another person to feel each stitch carefully made by a craftsman, inspired the first smart textile prototype. QR-coded Embroidery (2.1.1) unites prototypes and ideas that bring together folk-inspired embroidery on textile items and digital information layers via smartphone recognisable QR-code. One of the items, QR-coded Traditions (2.1.1.2), is a bright yellow pillow carrying a QR-code that after scanning with a smartphone application shows a cartoon of a fairy tale to the viewer. Conceptually the tale originates from the same area as the visual inspiration for the pillow.

Craft qualities in QR-coded Traditions

The struggles with the material guided the design process throughout the iteration from traditional crafts to QR-coded Embroidery. The output had to both look pleasing and work technologically. Considerable effort was directed into styling the code, designing it with vector software, and hiding the elements of the code, so that they would be only recognised by the smart-phone and not by the human eye. During the process it turned out to be more interesting to work with the colour variations keeping the original shape of the QR code. The struggles between the maker and the machine, resistance and inspiration ended up informing one another. The machine and the material limitations inspired the creative process. Challenges led to new directions. Letting the machine guide the design process, and in some aspects allowing mistakes and difficulties to guide the process, (Figure 47) had an interesting impact on the result. A remark from my notebook: “Several tryouts to design a complicated pattern failed whereas the simple change of thread and/or background colour gave a lot of opportunities to play with the looks of the QR codes” (excerpt from my notebook, 2012). I experienced what Sennett points out: “Machines break down when they lose control, whereas people make discoveries, stumble on happy accidents” (2008, p. 113).



Figure 47 The idea to combine colours in the embroidery came after the main thread finished while embroidering a code, and the embroidery machine automatically replaced it with another one.

Working with resistance means converting boundaries into borders (Sennett, 2008, p. 229).

The boundaries became the inspiration throughout the process of developing QR-coded Embroidery. The Muhu skirt, brought as an example of traditional folkloric costumes, inspired the colours used on the QR-coded Embroidery. They mean certain things to the people of a community who are able to read them. The pattern was designed with the inspiration from folkloric visuals, which are rich with meanings and vary according to the regions they belong to. Thus, the plain textile is “coded” with traditional craft information through the QR code links. As mentioned in my notes, “Having no experience with the embroidery previously, helped me to start without thinking too much, since I didn’t have any expectations” (excerpt from my notebook, 2012). Unconstrained by specific expectations, the process of making continued without pressure. Instead of thinking about possible solutions, the first concept was tried out in a rough prototype.

Upon seeing the prototype, Sims pointed out immediately that the machine embroidery is

definitely different from the hand embroidery; both visually and how it feels. She noticed that some threads were loose on the sample, and that not all the technique was perfect throughout the embroidery work. (Interview with Sims, 20.09.2013)

The experts valued the new approach taken to translate old textiles into modern contexts, the choice of colour that hinted at the cultural heritage. They suggested improving the conceptual value by making the embroidery by hand together with one’s grandmother. They also appreciated the possibility of either changing the story or keeping it as is, and pointed out that a child might choose a pillow as a favourite because of the story embedded into it. QR-coded Traditions are related to the community through the practise (making) as well as the concept of storytelling and sharing. The pillow is connected to specific values through fairy-tales.

The experts pointed out the values of this iteration to be the connection with ancestors’ culture and modern technology, colour selection, choice of technique (embroidery and not print). They underlined the craft qualities being the connection with the ancestors’ culture and wide possibilities to further develop the content. “I like the layering, how meaning and visual side come together” (Interview with Kabun, 22.09.2013). They also liked that the pillow did not carry any electronic components. The experts also appreciated the modern-minded language that created interest and provided information in a new way. “The value is for sure approaching young generation through something they understand and getting them introduced to history through an image/language they understand. First glance only historical pattern in a modern decorative way is actually containing a message that is readable only by the use of technology” (Interview with Kabun, 22.09.2013).

CRAFT QUALITIES IN SMART TEXTILES: 4.2.5 BEDTIME STORIES

Augmented reality could be compared to magic. It deceives the viewer into seeing something that is not there. Bedtime Stories (2.1.2) unites prototypes and ideas that bring together textile interaction and Augmented Reality storytelling through a tablet or smartphone application. One of the examples, Little Red Riding Hood (2.1.2.1), allows the parents to tell the traditional fairy tale by incorporating their personal values and changing the story as they see fit. The digital 3D characters of a flower, wolf and grandmother appear on the cloth after the tablet or smartphone camera has detected pre-registered markers.

Craft qualities in Bedtime Stories Little Red Riding Hood

Bedtime Stories focuses on the material engagement of interactive storytelling. Technology and textile are completely separated physically but can be seen as a material to work with for story creation. As in the previous iteration, the textile product gains potential towards longer life through the connection with the digital layer. It can remain interesting for the users because they can build their own stories onto the duvet cover. The fairy tales can be changed and updated over time. I value the importance of discovering possibilities through making. As noted: “Only after finishing the prototype could we discover that there is an interaction possibility between the textile and digital layer. When textile beneath the iPad is moved or other ways manipulated, also the characters related to the image on the cloth react and move” (excerpt from my notebook, 2012). The experts found material qualities in the woven prototype. For example, Sims said, “I like especially that it is woven and not printed” (Interview with Sims, 20.09.2013). They pointed out craft qualities such as the possibility to develop and improve the existing product over time. For Lampinen, the touch sensation played an important role in the textile quality

(Interview with Lampinen, 30.09.2013).

The experts mentioned craft qualities such as the possibility of creating new characters, new playing possibilities and the strengthening of the bond between the parent and the child (see Table 1). Bedtime Stories aims to enhance the family and community connection through storytelling. The experts appreciated the skillful connection of both textile and information technologies and the connection that appeared between these and the soft cultural values. They found the project represented innovative approach and layering. They mentioned that the project could attract a younger generation and bring fairy-tale knowledge closer to them. Craft experts pointed out some concerns as well. “At the same time it bothers me, that to listen to one fairy tale you need so many gadgets: the specific blanket and an iPad and an application. Kids brain could get the same stimuli from reading a book and seeing pictures. It disturbs me a bit that iPad comes into the intimate family time” (Interview with Ahven, 5.12.2013).

The aspect of surprise and the possibility of reviving fairy-tales through technology intrigued the craft experts as well. “The value is modern approach and comprehending the behaviour patterns of new generation. To create symbols and connections in places that strike as unexpected and stimulate opening of a new way of thinking” (Interview with Ahven, 5.12.2013).

Next, the craft qualities throughout the design process will be explained. The craft experts commented on the specific changes in the relation to craft values, when the QR-coded Embroidery project became Bedtime Stories.

4.2.6 CRAFT QUALITIES THROUGH THE DESIGN PROCESS

The QR-coded Embroidery was developed based on my personal background. When working on the Bedtime Stories, the team extended to a multidisciplinary group. The next section points out the aspects of the prototypes that changed in the transition from one iteration to another: first, from the traditional folk item Muhu Skirt, which is used as inspiration to create the smart textile concept of the QR-Coded Embroidery, and second, how and what changes when industry partners adopt the project with an entirely different set of skills and ideas for the development of the collaborative project Bedtime Stories. The craft experts commented on the similarities and differences in all three items.

Some common craft qualities are identified in the design critique. In the transfer from one iteration to another some values were lost and some were found. The following two paragraphs describe the similarities and differences in craft qualities between the examples Muhu skirt, QR-coded embroidery, and Bedtime Stories. As the project developed from a self-made folk embedded DIY example which works on QR-code recognition technology into a collaborative high-quality industrially produced, woven textile with Augmented Reality, the presence of craft characteristics changed along with the process.

Some other craft qualities that the experts identified in the design iterations remained or became greater in the development of the prototype. Sims observed, for instance: “The similarity between all of them is the connection with the person’s heritage or to say it better: the possibility to create new codes for defining your cultural legacy” (Interview with Sims, 20.09.2013). Also the storytelling, meaning creation and new interaction language were pointed out. Lampinen appreciated the story, storytelling, and the textile as a medium throughout both of the iterations. She noted that touch was the essential property of the project. Lampinen also liked the oppor-

tunities the Augmented Reality technology added to the story and the playfulness. (Interview with Lampinen, 30.09.2013) The experts saw communication as one of the primary pillars of the different projects. According to Ahven, both QR-coded Embroidery and Bedtime Stories were “Creating new meaning and communication language to the future user” (Interview with Ahven, 5.12.2013). Nimkulrat stated: “The common element between all these iterations is that there’s something more than you can see at first and the interactivity or the invitation to interact with it” (Interview with Nimkulrat, 5.12.1013).

The values related to the Estonian background got displaced with the multicultural, more generalised characteristics. Sims, for instance, appreciated the possibility of going back in time and playing with one’s heritage and roots. Ahven also valued the use of an ethnographic frame of reference in a new way. She pointed out the layering and multiple meanings as similarities between Muhu skirt and Bedtime Stories. “Bedtime Stories cloth gets a new meaning through the iPad application” (Interview with Ahven, 5.12.2013). Kabun expressed concerns about the declining presence of the traditional heritage in the project: “The connection with the traditions, unfortunately, remains less and less each step. If the Bedtime Stories weaving would include motives from the folk embroideries, or the colour scale would allow us to guess the connection with Muhu skirt, also the connection would be more visible” (Interview with Kabun, 22.09.2013). Kabun liked the storytelling aspect and mother’s connection to children. In general, the experts related QR-coded traditions more regularly to the original craft item Muhu skirt, with the emphasis on the colour and shape resemblance to the original ornaments. Nimkulrat said about The Bedtime Stories: “It’s not craft as such when I see this project because it’s immediately visible that it’s industrially produced” (Interview with Nimkulrat, 5.12.1013).

The original folk costume and the two compared prototypes relate to crafts on different levels. Muhu skirt is a traditional folk garment carrying all the craft-related qualities. QR-coded Traditions is an attempt to embed certain craft-related qualities into a combination of textiles and technology. Bedtime Stories, however, is a collaboratively developed producible prototype with no craft intentions. The craft qualities we could identify together with the experts common to all three items relate to hidden and layered symbols, which are creating meaning and surprise. In all the projects, the textile is used as a medium, a communication system or language of that time. They all relate to story and storytelling on some level. The project carries a particular connection to the heritage. Touch is an essential property in all example projects. They also share similar concerns about responsibility for the product and the production. They enhance family connection. The shown designs act as an open canvas for communication. They are changing and developing over time.

The next section of the chapter explains the first version of craft qualities as the redefined understanding of myself as the designer-researcher. It introduces each of the identified qualities in traditional crafts and Bedtime Stories project context.

THE DESIGNER-RESEARCHER’S REDEFINED UNDERSTANDING OF CRAFT QUALITIES 4.3

My personal understanding of the craft qualities in smart textile services changed when designing the smart textile examples as well as conducting interviews with craft experts. The redefined understanding captures the first version of craft qualities that become an input into the re-design of Bedtime Stories that results in Textales Dream Bear and Sunny Sunday editions. The craft qualities are presented in this section through their meaning in

traditional crafts as well as in the smart textile service example Bedtime Stories.

4.3.1 FIRST VERSION OF THE CRAFT QUALITIES

The set of craft qualities (K. Kuusk, Wensveen, & Tomico, 2014) is found as a result of the previously presented interviews with the craft experts. In the round of interviews, the craft experts compared the traditional Muhu skirt to the two smart textile projects, QR-coded Embroidery and Bedtime Stories. The three smart textile objects were presented to the experts so they could point out similar features among them. What emerged is not a final and complete list of all the craft qualities nor the most important ones. It is a set of qualities encountered within the traditional crafts and smart textile services examples, QR-coded Embroidery and Bedtime Stories. The members of the project and interviewed craft experts identified the preliminary set of qualities. The first version of craft qualities was drafted based on the interviews and it expressed my redefined understanding as a designer-researcher. The found craft qualities could inspire smart textile services to be designed from a sustainable starting point. They allow the services to emerge from the need and meaning in the society, carrying traditional values.

The craft qualities found in both – traditional crafts and smart textile examples – become the first version of craft qualities. Considering all craft experts’ suggestions and ideas through my lens of smart textile designer, resulted in a set of craft qualities present in traditional crafts as well as in the smart textile examples. The identified nine craft qualities (CQ) are: Embedded Meaning, Material as a Medium, Hidden Stories, Heritage and Tradition, Touch and Feel, Societal Responsibility, Family Connection, Open Source Community, Evolution in Time. Those craft qualities serve as inspiration for the re-design of the smart textile service proposal Bedtime Stories into Textales Dream Bear edition and Textales Sunny Sunday edition. Each craft quality will be explained first from the traditional craft perspective, and then how it appears in the Bedtime Stories Little Red Riding Hood project. My redefined understanding of the craft qualities will be presented through this.

CQ1 Embedded Meaning in traditional crafts departs from the community’s ability to store “coded” information in the folk garments. It is about local people adapting currently important meaning to the universal symbols and using those unique and personal representatives to tell a story of that time in their community. In the first industrial design experiment, Bedtime Stories Little Red Riding Hood, the application reveals digital but static 3D characters once the tablet has recognised the defined image on the duvet cover (Figure 48). The extra layer is visible only through the tablet device in a particular application.



Figure 48 The camera of the iPad has recognised the marker on the Bedtime Stories duvet cover, and the application projects the 3D character in the Augmented Reality layer.

CQ2 Material as a Medium in the context of traditional crafts means the material properties and knowledge inherent from the environment and the maker or craftsman. For example, the Muhu skirt orange-yellow colour originates from the sea mines that were washed up at the local port in 1930, where Muhu women got the necessary yellow tone for the yellow skirt yarns (Puppert, 2011, p. 159). It stands for the craft’s characteristic to mirror current time, always renewing. Also in Bedtime Stories Little Red Riding Hood, the embedded fairy-tale, being digital content, could potentially change over time. The additional digital layer enriches the textile. The interaction of textiles and technology communicates the stories to the users (Figure 49).

CQ2
Material as
a Medium



Figure 49 A mother telling the Little Red Riding Hood fairy tale to her kids via the iPad application.

CQ3 Hidden Stories in traditional crafts act in the way traditional costumes once carried public and personal stories. The weave of the fabric has stories embedded in it. The meaning of the narratives and the “code” to read them could, however, change over time. For example, the side on which a man wore his mittens on the belt revealed his marital status. In Bedtime Stories Little Red Riding Hood, the fairy-tales hidden in the duvet cover (Figure 50) are the essence and fundamental value of the project.

CQ3
Hidden
Stories



Figure 50 The fairy tale of Little Red Riding Hood, with the characters of grandmother, wolf, and a flower, is hidden into the woven duvet cover.

CQ4 Heritage and Tradition in traditional crafts stands for the custom of passing crafting skills on to the next generations in the family and community. “It was thought to be her mother’s fault when a girl could not manage handicraft” (Summatavet, 2005, p. 69). It was also customary to fully use textile pieces, since material was extremely time consuming to make. In Bedtime Stories Little Red Riding Hood, the soft values that are embedded in the technology in the project create the connection with the heritage. Traditional relevant stories carry human values along family by family. The stories shared in a new way (Figure 51) give a modern view of the community to the traditional story.

CQ4
Heritage
and
Tradition



Figure 51 A mother explaining her values to the kids through the playful story of Little Red Riding Hood.

CQ5
Touch
and Feel

CQ5 Touch and Feel in traditional crafts build on the way many craft items invite touching. It is almost like they are expected to feel different than they look. Depending on the thickness and material of the thread, woven textile varies from smooth to rough. An experienced hand can easily distinguish a printed image from an embroidered or a woven one. In Bedtime Stories Little Red Riding Hood, touch is an essential property achieved by the use of the high quality woven textile. A touch of the textile remains the main trigger for the digital interaction (Figure 52).

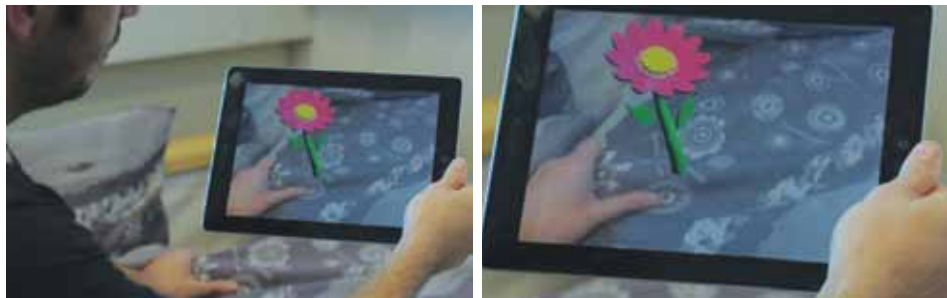


Figure 52 The digital character in Bedtime Stories Little Red Riding Hood can be manipulated only through the touch on the textile.

CQ6
Societal
Respon-
sibility

CQ6 Societal Responsibility in traditional crafts celebrates the distinguishable style of each craftsman that made it possible for a craft object to be traced, where the material came from, who designed and created it. The item's making process forms a story with its embedded meaning in the specific community. The material's scarcity and local lifestyles allow nothing else than local and high quality materials and production. In Bedtime Stories Little Red Riding Hood, the production steps from creating the textile onwards have been closely followed by the project partners involved in producing the sample. We have used local and high quality materials and production methods (Figure 53).



Figure 53 The durable cotton textile carrying Bedtime Stories Little Red Riding Hood is woven in Gemert in the Netherlands.

CQ7 Family Connection in traditional crafts represents the shared time and stories that were part of many crafting activities, for example, the custom of gathering together all women of the family when making the traditional mittens and other textile items for the wedding ceremony and dowry.

CQ7
Family
Connection

As important as the craft objects themselves were, there was also an underlying agenda to share stories and experiences of the two uniting families. Group connection through crafting has also been used in therapy (Corkhill, 2014). In Bedtime Stories Little Red Riding Hood, the family connection is envisioned to grow through the time and stories shared on the duvet cover (Figure 54). It is realized by providing together time and story inspiration for the family through the combination of the textile and tablet application.



Figure 54 A mother is asking questions about the characters of the Little Red Riding Hood story from her child. The child is trying to capture the digital character with his hands.

CQ8 Open Source Community in traditional crafts is based on their reputation for being open (within a certain community) and developing in directions guided by the community of crafters. The patterns and techniques for handicrafts, for example, are shared and passed on within the family and community. They are also borrowed or adapted from other communities' creations. They get applied to the current local context and relevant issues. For example, there were different modifications of Muhu skirt in time: red, orange, and yellow, due to the available materials and skills of the specific period. Bedtime Stories Little Red Riding Hood uses open canvas for communication (Figure 55). The textile has the potential to become dynamic and usable as a communication tool.

CQ8
Open
Source
Commu-
nity

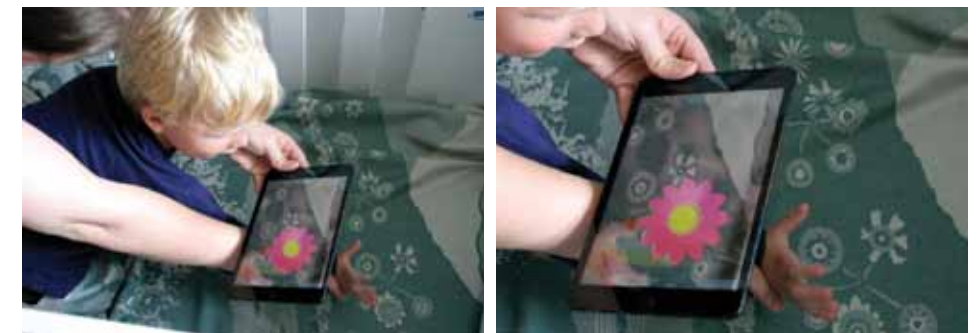


Figure 55 Through the symbols and references of the Little Red Riding Hood story different topics can be shared between the parents and the children.

CQ9 Evolution in Time in traditional crafts is about their constant change. The standards, skills and also the ideas present in crafts depend on the community and the craftsmen working in it. The crafts gradually change due to the environmental, material or mindset changes in the community and in the craftsmen. The Bedtime Stories Little Red Riding Hood project is changing and developing over time. At first the change was through the iterations, and later perhaps through the supporting community. The possibility of creating new data, characters or stories over time (Figure 56) and extending the application to different platforms is a way to show some possible directions. Evolution in Time gives potential for a service model to naturally occur.

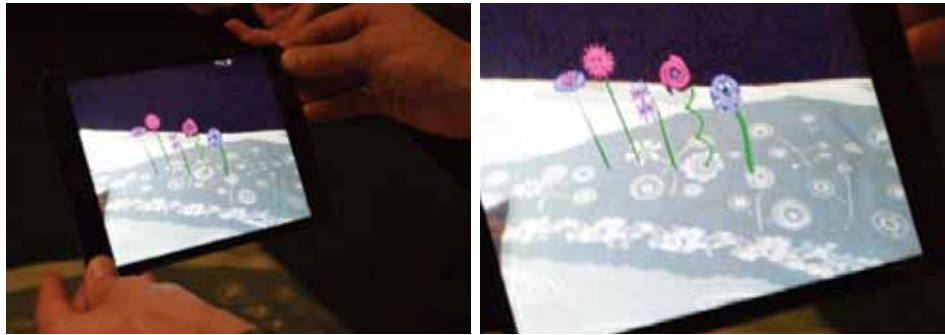


Figure 56 At a certain point of the project, the static pink flower that was always found near the flower fields of the duvet got replaced by a dynamic row of flowers that would move along according to the way the textile was touched.

The next section demonstrates how the identified craft qualities guided the re-design of the Digital Stories on Textile project. It shows emerged requirements for the textile and application and how they were implemented.

4.4 REDESIGN OF DIGITAL STORIES ON TEXTILE

This section is about re-design of the smart textile services example Bedtime Stories, resulting in Textales Dream Bear and Sunny Sunday editions. It shows how the first version of the craft qualities, presented in the previous section, influenced the re-design of Digital Stories on Textiles project. The previous design iteration made the craft qualities explicit in a smart textile project. The next iteration shows how the craft qualities in combination with the sustainability qualities (Chapter 5) guided the design project.

4.4.1 APPLYING THE FIRST VERSION OF CRAFT QUALITIES

The previous section presented my new understanding of craft qualities in the traditional crafts and smart textile example Bedtime Stories, as the redefined understanding of the designer-researcher. These qualities influenced the design process as I started to collaboratively develop the next iteration of Digital Stories on Textile. The previous iterations were driven by material as a mixture of textile, technology, culture, and my personal history. They were explorative and opened up more possibilities at every step of the process. They were about finding as many different directions for the work to develop as possible. Now, having concretised

the first version of craft qualities, I could use them as a filter or a guide, to focus the project towards a concrete, clear direction. It helped me to make decisions. During the design process, I could always return to the first version of craft qualities and see how the question in hand related to the list of qualities. On a practical level, when developing the concept and design/technology requirements for the new iteration, I took into consideration the following aspects from a craft quality point of view:

- Surprise, hidden, secret;
- Personal and known stories, updatable;
- Traditional fairy-tale with a contemporary twist;
- Local, regional story;
- Interaction through textile only;
- Sustainable textile materials;
- Family interaction is the base for the story;
- Users can make and change stories;
- Open stories, sharable.

The moment of reflection on the craft qualities in between the design process helped to give value to the previous explorations and a clear direction for further development. Through allocating the craft qualities in the different iterations, I could find some implications for the future service. The final application has to support and strengthen the family connection. The stories need to be personal and should be able to grow and change in time. The whole family should be able to design characters and elements for the story. The families should be able to share their unique story versions. The experts recognised the high-quality materials, storytelling and textile as a medium as craft qualities in Bedtime Stories. The stories should be location specific. People could share stories in different settings in different cultures. For example, default stories and possibilities to repeat stories should be provided. The application has to be multi-platform and support different devices. The textile should be produced locally and support the various communities in practise.

These craft considerations would make the service convey sustainable cultural values through the use of contemporary media and way of living. The combination of the crafting perspective and the service design perspective contributes to the paradigm shift needed for smart textiles to be environmentally, economically and societally meaningful and sustainable.

The craft experts reviewed the developed first version of craft qualities in the context of Textales. The next section of this chapter looks into the developed iterations Textales Dream Bear and Sunny Sunday editions.

4.5 CRAFT QUALITIES IN TEXTALES

This section explains the methods for collecting and analysing the data from confronting my redefined understanding of craft qualities with the craft experts. The redefined understanding of the craft qualities in the traditional Muhu skirt and in smart textile re-design Textales was presented to the experts to validate and enrich my understanding of the craft qualities. The results from the interviews will be presented in the second version of craft qualities.

4.5.1 METHODS FOR COLLECTING AND ANALYSING DATA

The first version of craft qualities was brought back to the craft experts for further study. The reviews focused on locating the craft qualities in the traditional craft example: the Muhu skirt and the re-design of Bedtime Stories project, Textales. I met Nimkulrat and Ahven in their workplaces at the Estonian Academy of Arts and Kabun in a cafe in Tallinn. Other previously interviewed experts were not available this time.

During the review sessions, my redefined understanding of the craft qualities in smart textiles was introduced to the craft experts in the form of the first version of craft qualities. The craft qualities and their explanations were described to the experts by labels and meanings. The craft experts were asked to comment on the craft qualities and my redefined understanding of them to validate and enrich my knowledge of the craft qualities. The craft experts were encouraged to point out how they saw each craft quality present in traditional crafts, e.g., Muhu skirt, and the smart textile service concept Textales. They were also asked to comment on the craft qualities in general, if they notice anything they found should have been different. The reviews lasted approximately one hour each and were kept relatively open to enable the participants to give their opinions at ease. The data were captured in notes and audio, which were transferred into a table (Table 2) showing the reactions of craft experts during the review in a compact way. My redefined understanding of the craft qualities in smart textile services that was described previously is also included in the table.

4.5.2 RESULTS FROM THE CRAFT QUALITIES REVIEW

The following section presents my redefined understanding of the craft qualities in the smart textile services context and the insights gathered from the meetings with the craft experts Nimkulrat, Kabun, and Ahven. For the complete overview of the interview results see Table 2.

For example, I defined the Embedded Meaning (row 1, column 1) craft quality in Muhu crafts as “Unique patterns are used to tell a story, to be unique and better. General symbols are used to protect and represent other magical powers. The patterns and symbols are only known to a certain community” (row 1, column 2). Nimkulrat commented on seeing one traditional line that does not change and a second – personal – line, that was more unique (row 1, column 3). Kabun brought an example of the red colour and specifically the red tack thread for the skirts and jackets being a protection thread (row 1, column 4). I defined the Embedded Meaning craft quality in Textales as “Image recognition revealing digital characters when certain defined image (symbol) is scanned. The content is only revealed through a certain lens and program” (row 1, column 6). Ahven commented on it: “Community gives the application the meaning. Only if

you’ve read the Little Red Riding Hood tale, the wolf carries a different meaning for you. It gives the context” (row 1, column 9).

The next section explains each craft quality first through the comments of craft experts; how they see that quality in the context of traditional crafts and in the Textales smart textile proposal. It combines my reflection on the quality and craft experts’ input in traditional crafts, Textales Dream Bear and Sunny Sunday editions. At the end of each craft quality description a short definition for the craft quality is added.

SECOND VERSION OF THE CRAFT QUALITIES EXPLAINED THROUGH THE TEXTALES DREAM BEAR AND SUNNY SUNDAY EDITIONS 4.5.3

Textales is a third iteration of the smart textile project Digital Stories on Textile. The concept, first explored in QR-coded Embroidery, further developed into Bedtime Stories and finally resulting in Textales, brings together traditional textile and Augmented Reality through storytelling. Textales Dream Bear and Textales Sunny Sunday editions are two parallel developments of the project. Textales Dream Bear edition allows exploring the craft qualities from a commercial starting point. It’s a market-ready prototype carrying one custom made story. Textales Dream Bear was developed in collaboration with a local storyteller-illustrator, a software company and a textile producer to provide Augmented Reality experience in textiles. Textales Sunny Sunday edition allows exploring the craft qualities from an open DIY angle. It was developed in collaboration with a group of friends and a textile company. It exemplifies the possibilities to create new stories, or store personal or group information in a textile.

The second version of the craft qualities is presented through first describing how the craft experts find each quality in traditional crafts and in the Textales smart textile service project. After the inputs from the interviews, my reflection on the gathered information is presented. The reflection is shown through two exemplary projects: Textales Dream Bear and Sunny Sunday editions. At the end of each craft quality explanation, the craft quality is summarized for a clear reference. Therefore the following contains in-depth insights into each craft quality in the smart textile service Textales context and a generalized definition applicable to other fields.

CQ1: EMBEDDED MEANING

In traditional crafts

The experts pointed out the contrast between the two faces of Embedded Meaning – one being the non-changing traditional way, and the other personal, unique way of planting meaning into crafts. It is also believed that the general look of the folkloric costumes could say something about where they come from based on the materials, shapes and colours used in them, but the patterns had to be unique and tell a story. Illustrating the beliefs of how craft objects were believed to protect, cleanse and empower people wearing them, Kabun points out the importance of the red tack thread on garments, which was thought to protect the wearer.

In Textales

The craft experts appreciated both the aspect of the image recognition revealing digital characters when a certain defined image is scanned and the content only being exposed through the tablet application as parallels between the traditional crafts and Textales application. The experts pointed out the value of the community in giving the application the meaning. As Ahven said, “Only if you’ve read the Little Red Riding Hood tale, the wolf carries a different meaning for you.” The

LABEL	HOW DOES THE CQ APPEAR IN MUHU CRAFTS?				HOW DOES THE CQ APPEAR IN TEXTALES?			
	Designer-researcher	Nimkulrat	Kabun	Ahven	Designer-researcher	Nimkulrat	Kabun	Ahven
Craft quality name								
Embedded Meaning	Unique patterns are used to tell a story, to be unique and better. General symbols are used to protect and represent other magical powers. The patterns and symbols are only known to a certain community.	One line traditional and doesn't change; second line personal, unique.	Red color. Red tack thread (traageldusniit) for the skirts, jackets was a protection thread.		Image recognition revealing digital characters when certain defined image (symbol) is scanned. The content is only revealed through a certain lens and program.			Community gives the application the meaning. Only if you've read the Little Red Riding Hood tale, the wolf carries a different meaning for you. It gives the context.
Material as a Medium	The materials and items tell a story about the location and people they are made by. Muhu skirt is yellow because of the mines in the water where the yarns were died. It is woolen skirt to fit into the Nordic weather.	2 types of environments: natural environment, man-made environment. It's a visual language.		It's about telling the story of a place and time. In the case of Muhu skirt people lived in one place. Muhu skirt was decorative, made in that location.	Textile is used to share and tell popular or personal stories. The stories are embedded into the weave, but they can also change over time.	The story comes from the pattern. It's a visual language.	Stories from the parents. What did they do when they were young? Personal stories.	There are limitation by place and time. We cannot give the same meaning to textile today. Even though we expect the same form a garment. Innovative textiles allow new functionalities. It's about telling the story of a place and time. Today people are global and the stories are global. The smart textiles are becoming the medium between the people and the environment.... it has modern context in terms of the material - new technology gives the last meaning and finishing layer to the textile. The stories only get meaning through the technology.
Hidden Stories	Only married women wore a certain hat. Men wore their mittens in different sides on their belt based on their marital status. A widow was recognised by her clothes.	Made up code.	People were following a certain tradition of how the symbols were used.	The story used to be in the imagination of people.	The fairy tales are hidden into the blanket.	Straight forward story.		The imagination is coming to the blanket. The stories are able to change, if people are able to manipulate them themselves. Tales are <i>virtually</i> hidden. The fairy-tale gets a meaning only <i>with</i> the technology. As in fairy-tales the local and nationality and the cultural story plays a role. It's a story of the moment and time that is being transferred. The manner (kombestik) lives on with the people. If the people mix, also the manner and traditions mix. Storytelling has an important aspect of craft in the Textales project. it has to be crafted story.
Heritage and Tradition	It was fault of the mother if Muhu girl didn't know handicraft. She was missing some skills for life then.	Knit is triangle and weave is square pattern always could be part of the embedded meaning.	It was part of daily life, same as learning how to make food, woodwork, handycraft.		Local stories giving the modern view of the community to the traditional story. Parents telling stories for kids.	Old story - new technology.... Passing on knowledge, history told through a different language.	Educative moment, old stories from the parents, sharing the values through stories, modern version of fairy tales.	Possibilities for alternative stories, softer stories. It opens up old fairy-tales, allows people to create their own fairy-tales.
Touch and Feel	Knit is triangle and weave is square pattern always. The material comfort importance on the body. Embroidery's touch in the initial work.	Knit is a soft structure, weave is not as soft.... Construction of the fabric having influence on the body. The way that it feels tells it is craft, it is handmade.	Following a tradition. I don't think someone was analysing by then. They just followed the traditions: wearing linen in summer and wool in winter, because this was how it had been done always. Higher quality linen was used in shirt and lower quality in a skirt, and sometimes the materials were changes. There were long shirts-upper part made of one material and lower part made of another material. Kihnu korts were worn in all different ways, nobody washed them. the stripes coloured with plants would not have survived the washes. Korts were assembled from two worn our Korts. even coats were changes inside out when materials got too used.	The feeling and love is put into the items with making them by hand. It feels different than line production items. It has hidden human warmth feeling.	Interaction in the fairytale is only by touching the textile. Not the screen.		Further development could be to work on more structural surfaces.	Perhaps should be part of material as a medium?
Societal Responsibility	Muhu well-known crafters had their own style, which was recognised.				Local and high quality materials and production.		It's valuable to keep something consciously local (as Oscar Metsavaht's work), to think about afterlife, waste problems, cradle to grave, thinking through the whole cycle.	New local - the community based local. The sense of local has changed.
Family Connection	Making mittens before the wedding was a custom to share the stories about the families.	Traditional way of making textile.	There was no choice, life was static in one place, everything was local.	Local.				
Open Source Community	Different Muhu skirts in time: red, orange, yellow. Inspiration for the Muhu embroidery came from Lääne county because the island girls were working there.	Pace of change is the difference: slower pace.	There was no choice, people lives very closely together in small spaces. Today everybody is spreaded. "videviku tunni pidamine" to have an hour for sun-set, was there to share all the stories with the family.		Family connection through the shared stories.	Textile as the interaction mediator.	The creation and valuing of the family time; the application is a trigger to bring that time forward.	It's a tool for communication, to create quality time in the family.
Evolution in Time	With UKU the Muhu items got standardised which on one hand helped to document and on the other hand stopped some of the more complicated styles and techniques, went into mass production not changing anymore.	Evolution in two directions: 1.industrial technology - simplified; 2. complexity or style of the pattern - to develop.	UKU: hand made but production. There are differences: craft, handmade, and piecework.	If the items get simplified the feeling they embed and carry gets degraded. Ethnographic pattern in another context (for example in another dictatur) gets a different meaning, therefore the new generation needs new symbols.	Users being able to make new stories and change the existing ones according to their will.	Pace of change is the difference: faster pace.	Technological solution but easy to use.	
					Community based: new developments in software and stories, sharing.			The skill of telling the story is so essential for the project.

knowledge of the community gives the context to understand the symbols – digital or not.

Reflection of the designer-researcher

Each person looking at a craft item, or any object at all, sees it from their viewpoint through their own lens of cultural and personal experiences. When Niinimäki (2011) talks about the meaning of clothes and the ways of increasing that meaning, she points out how the meaning could be embedded into craft items through the message that is communicated via the symbols, colours, or other aesthetic features. When a knitter places protective symbols into a mittens pattern, it is not obvious that the person wearing them would necessarily know the meaning. Therefore, the Embedded Meaning craft quality is about the person embedding information — the maker. It is about the craftsman giving his meaning to the item. It is about telling the story of the creator and how they become part of the craft object. Individual meaning that is formed by the community should always have a unique touch. Craftsmen working on Muhu island hundred years ago did not think much of craft pieces that looked the same. They saw the repetition of the same patterns as stealing all the magic from the patterns. (Kabur et al., 2010, p. 6)

In the design example Textales Dream Bear edition, it is clear that the digital augmentation layer is “coded”. Using a tablet or smartphone device, which has the developed application running on it, is the only way to access the digital content. For the human eye, the pattern seems to be a beautiful woven scenario of a bear’s adventures in the woods. It takes a computer with a certain program to detect all the defined areas on the textile and display Augmented Reality content connected to the specific locations. The development team makes the connections between the markers and the digital content. The user can work with the existing imagery and setting to adapt their story and meaning to the suggested one. The family can play with adding physical items to the textile duvet and download new seasonal/popular/custom digital data provided by the developers for the application.



Figure 57 A drawing of a house representing the home of one of the characters in the Sunny Sunday story.

The digital information is similarly “coded” in Sunny Sunday edition. It can only be accessed via a smartphone or tablet device with the specific application. However, the community makes the connections between the markers on the cloth and digital appearances. The users themselves have created the characters and connected their photos or videos to the specific locations (Figure 57) on the material. Therefore, at any moment in time, users can add, change and remove digital content attached to the textile.

Embedded Meaning is the “coded” tacit knowledge the maker gives to the object. It is about telling the story of the craftsman and how it becomes part of the item. It can be well known within a group or personal, expressing uniqueness.

Definition

CQ2: MATERIAL AS A MEDIUM

In traditional crafts

When talking about material being a medium the craft experts recognise two types of environments giving impacts to the material: the natural and the man-made environment. Nimkulrat mentions how something that used to be defined from environmental contamination (Muhu skirt being yellow), is nowadays achieved by chemical dyes. The experts confirm the material as a visual language. They find the craft to be telling the story of a particular place and time. In the specific case of Muhu skirt, the craft experts point out the importance of remembering how people lived on one island 100 years ago and how the decorative skirt was made in that exact location. People did not move or relocate too much then without a serious reason.

In Textales

Craft experts appreciate the notion of using textile for sharing familiar and personal stories. They note the stories on the duvet cover originating/coming from the pattern itself. In that way, they see Textales as a visual language. Kabun values most the idea of communicating and storing the personal stories of the parents. She envisions the cloth carrying insights about the parent’s past activities and adventures. Ahven vividly points out the limitations of place and time. She notes that, even though we expect the garment to protect and keep us warm as before, we cannot give the same meaning to it as it used to have 100 or more years ago. Ahven mentions appreciating new functionalities that innovative textiles could open up for clothing. Talking about the project, she points out that “It’s about telling the story of a place and time. Today people are global, and the stories are universal.” She sees how smart textiles could become the medium between people and the environment and appreciates the modern context of Textales regarding the material. She finds the new technology gives ultimate meaning and finishing layer to the textile in Textales project. The fact that the stories only get meaning from the technology puts it into the current context to tell the story of the time and place that is heavily influenced by technology.

Reflection of the designer-researcher

Material as a Medium speaks to the user/viewer. In this case, the object already has embedded meaning and a story to tell. The user might find out the original story of the craftsman, but in any case it will be seen through the eyes of the user, in his time and space in the context of his experiences. Hummel and Levy (2013) talk about meaning being in-between the human being and the world. Referring to the phenomenology of perception by Merleau-Ponty (1962), they explain how meaning is created in interaction because people perceive the world regarding what they can do with it. The material, being exactly in between the individual and the world, helps the user to make sense of what he is experiencing. Some of the meaning embedded in craft objects is invisible to the eye and only known by the beholders. A concept such as Textales allows some of the magic hidden in crafts to become visible. According to Tharakan (2011), craft objects represent elements of an individual’s identity. Talking about material consciousness, Sennett (2008, p. 120) describes how the craftsman in each person depends on the curiosity about the material in hand. Therefore, considering the craftsmen aspects of the makers, they all have planted their individuality into the final designs of Textales.

In Textales Dream Bear edition, Zabransky, the storyteller-illustrator invited to work on the project, contributed professionally with her detailed and holistic style of drawing and storytelling. She also gave part of her identity to the project via the story she chose to share. Her passion for

woods, animals, and camping is clearly communicated both in the textile duvet design as well as in the digitally appearing characters. The Augmented Reality developers from Unit040 involved in the project contributed to the technical knowledge and build up of the characters. They made sure the content envisioned by Kerstin would come together in a user-friendly application. The weaving partners involved in the process gave generously of their textile knowledge and time to the project. Both Dream Bear and Sunny Sunday editions carry the identity of Johan van den Acker Textielfabriek in the way the design has been constructed into the fabric.

The users added their personal input to the Textales Sunny Sunday edition. The picnic sheet follows the drawing style of Iluescu-Jack. Makers together brainstormed and came up with the objects to show on the picnic cloth. The digital content is crafted bit by bit, and added at different times. Jack's 3D characters and scenes carry architectural references and hint at his professional background. A 3D flower modeled by the designer-researcher, also part of the Sunny Sunday picnic sheet, might not look like much, but carries memories from a fine day of crafting together. The material is more expressive to the makers, who embed the meaning into it in the first place. It carries their identity. If the user becomes the maker, as happened in Textales Sunny Sunday edition, the lines blur and support more meaningful items to appear.

Definition **Material as a Medium speaks to the user/viewer. The object has embedded meaning and a story to tell about the natural and man-made environment of its origin.**

CQ3: HIDDEN STORIES *In traditional crafts*

The craft experts saw the way that folk costumes were communicating hidden stories as a code created by the community. They pointed out that people followed a particular tradition of how the symbols were used. The craft experts also pointed out how important the role of people's imagination was in carrying and developing that story. The narrative was in the imagination of people, who interpreted certain symbols according to their knowledge about the meanings of it.

In Textales

The craft experts found the fairy tales hidden in the blanket as a straightforward story in the duvet textile. Ahven pointed out the main difference between the traditional craft and Textales being that in Textales the imagination comes to the blanket. The stories can and would change in time only if people can manipulate them themselves. She appreciated the stories being "virtually" hidden and getting meaning only "with" the technology. She found the parallel between fairy-tales, where locality and nationality with the cultural aspects play a significant role, and Textales, which is a story of the moment and time. She wondered further about the manners and customs developing with the people. She pointed out how nowadays people living in different places also form combined traditions and ways of living. Ahven emphasised how important the storytelling aspect in Textales was, and valued the craftsmanship needed to build up an interesting story.

Reflection of the designer-researcher

The way that stories can be hidden in craft pieces and the process of making them is inspiring. They live mostly in the imagination of the craftsman and the viewer or user. The stories might be anchored by symbols, colours, signs, or smells, and yet mean something unique to every viewer who experiences the craftwork, depending on their background. "Illusion and transformation are twins of meaning making. Media forms that involve illusion and transformation can give aesthetic power to expressive statements about the human condition. We imagine worlds using media in order to make sense of the human condition" (Harrell, 2013, p. 337). The Augmented Reality stories hidden in the textile bring that highly imaginative process to a different level.

The imagination becomes digital and moves onto the textile canvas, as pointed out by the craft experts.

Even though Textales Dream Bear edition carries a relatively limited story, it can be told differently depending on the age of the child. The application provides characters with small adventures, but the family can imagine the story. Parents' experiences become part of their storytelling experience, and, therefore, highlight different aspects of the suggested narrative.



Figure 58 Textales Dream Bear editions invites the children to imagine the magical characters.

The meaning of the story carried in Textales Sunny Sunday edition changes along with changes in the group of friends. People go through individual and collective experiences, which change the way the symbols are seen. The "code" of the project is made, carried, and changed by the community itself. Traditions within the community can remain or be exchanged for new ones. Both the physical cloth and digital content allow that to happen. For example, a patch representing the new home of a friend who moved to another country could be placed on the textile and connected to the blog of her adventures in the new location.

Hidden Stories represents the narratives attached to certain materials and objects, either in imagination or in technology.

Definition

CQ4: HERITAGE AND TRADITION *In traditional crafts*

Kabun mentioned how learning handicrafts was part of daily life, in the same way as learning how to cook or work with wood. They were all essential skills for building a valuable life in a pre-industrial Estonian home and typically learnt by watching and helping the parents in the specific works.

In Textales

The craft experts compared telling an old story through new technology to passing on knowledge and history through a different language. They pointed out the educative moment in parents sharing their old stories and passing on their values to modern versions of fairy-tales. They appreciated the potential to alter the traditional stories with softer and different versions

better suited to the current understanding of the world. The craft experts found that opening up old fairy-tales would allow people to create their personal fairy tales.

Reflection of the designer-researcher

Reading books for children could be a tradition in some families. Playing and reflecting about the daily activities could be frequently done as well. Textales storytelling can be another way of interacting with kids through tactile experience of the textile material and magical digital worlds. Based on feedback during exhibitions, fathers and elder brothers seem to be more comfortable with technology and see Textales as an opportunity to bring the storytelling moment with the children and siblings closer to them (Figure 59).



Figure 59 An elder brother sharing a playful moment with his siblings using Textales Dream Bear application.

In Textales Dream Bear the storytelling could become a tradition, carried on as crafts. The Dream Bear story can be told by passing on values with it. Perhaps the values can be experienced rather than heard. The storyline can vary, but doesn't have to, since the application allows different modes of storytelling. The same characters can be met during the adventure in the storyteller's envisioned order, which is the default in the application. They can be also met randomly, challenging the parent to come up with an interesting storyline on the spot. And as a third option, the characters can appear in the order of markers appearing in the tablet's camera. This allows the parent to craft a story based on his or her personal preference.

In Textales Sunny Sunday edition, the emphasis is more on adding new inputs into the story. The action of adding a new element invites the person to reflect on how it fits the existing canvas, how it is related to the heritage. The tradition needs to be changed from time to time to understand how changes are an essential part of development. Different elements get more focus and attention at different times. Through the process of creating and remaking the canvas, the users learn from each other and grow a common pool of knowledge.

Heritage and Tradition is about passing on knowledge, to share the life lessons as stories.

Definition

CQ5: TOUCH AND FEEL

In traditional crafts

When talking about touch and feel, the experts emphasised the property of knit being a softer structure than weave and the way construction of the fabric influences the body. For an experienced person, it is possible to recognise whether a particular textile is hand-made or machine-made. Kabun points out, however, that people 100 years ago did not analyze what feels better, but just followed the tradition known to them. It was customary to wear linen in summer and wool in winter because this was how it had always been done. Higher quality linen was used in shirts and lower quality in a skirt, and sometimes the materials were changed. There were long shirts with upper parts made of one material and lower parts made of another material to suit the desired feeling. Kihnu kört [a type of apron] was worn in all possible ways; nobody washed it. The stripes coloured with plants would not have survived washing. Körts were assembled from two worn-out Körts. Even coats were changed inside out when materials got too used. The experts also appreciate the feeling and love that is put into the items when made by hand. Ahven: "It feels different than production line items. It has hidden human warmth feeling."

In Textales

The craft experts appreciate the bodily interaction in the fairy-tale, how it is in contact with the textile as opposed to the tablet screen. They suggest developing the structure of the textile surface itself further. They also point out that perhaps the touch could, instead of being a distinctive quality, be part of the material as a quality of the medium.

Reflection of the designer-researcher

Sennett (2008) talks about material-engagement as part of the craftsmanship approach as "basic human impulse, the desire to do a job well for its own sake" (p. 9). Being in constant contact with the material allows the maker to relate personally to it. Nimkulrat (2009) refers to craft items as the objects or outputs of experience. It is even said that through the craft object or pattern the user, viewer, or wearer can touch the craftsman behind the creation of the item. It becomes a bridge between people and times. Through the use of traditional textiles in combination with current technologies, perhaps a bridge could be created between the soft values of the past and the possibilities and knowledge of today.

The inquiry to develop further the surface triggers thoughts such as: what if the surface could change its shape according to what happens in the story? What if the digital characters could react to the shape change happening in the duvet? What if certain locations in the textile could soften or stiffen based on the development of the story?

Both Textales redesigns invite touching. People like to move their hands on the high quality woven textile. They also like to reach for the digital content. They are surprised when the flowers or characters disappear or react to their movement. Maybe in their mind there is a small hope of actually feeling a flower, a wish for some magic.

In Textales Dream Bear edition, the kids play with the digital characters by moving or manipulating the textile. By doing so, they understand how the characters are "attached" to the fabric and move along, once it relocates. It almost appears as if they are touching the fabric and also the fairy-tale at the same time.

When thinking along the lines of finding possibilities to develop the textile surface further,

Textales Sunny Sunday edition allows some try-outs. The concept allows different structures as patches (Figure 60) or objects as attachments to be added to the canvas. They can always be connected to the old or new digital content. The very low-tech experiential way would allow the designer-researcher to find out possible interesting directions for that idea.



Figure 60 Patchwork blanket with structural patches, photo: Berit Sander.

Definition *Touch and Feel is about appreciating the tactile properties of materials while making and also while using the objects.*

CQ6: SOCIETAL RESPONSIBILITY

In traditional crafts

The craft experts saw societal responsibility as an inevitable feature of the times. Everything was local and that was the only way to do things. Life was static, and lived in one place. Resources were scarce and had to be treated carefully.

In Textales

The craft experts found it valuable that the project team had considered local production and high quality materials for the production of Textales samples. They found it valuable to keep something consciously local, to think about an item's afterlife, waste problems, cradle to grave systems. Thinking through the whole life cycle of the product was pointed out. The experts also noted the importance of redefining the sense of "local" into a community rather than geography-based notions.

Reflection of the designer-researcher

Yuri Na {*Na:2012tz} defines craft as a "creative activity by humans whose aim is the aesthetic functional object, realized from its whole life cycle as finished object, practise of making process, and services" (p. 15). Today it has become almost impossible for a designer to trace the origins of every component of what they design and produce. As a consequence, there is a lack of a larger picture and responsibility is distributed over the whole production process. Through technology and trusted connections, the shared responsibility could be found.

In Textales Dream Bear edition, the style of the illustrator can be recognised. However, in the current set-up of the textile production system it does not say much about the whole development process of the product. For Textales Dream Bear edition, the weaving partner chose the textile materials carefully. For raising general awareness, the items have extensive information on the labels (Figure 61) stating in very clear simple language how the items should be cared for. The text on the label reads:

"We have made sure to produce Textales Dream Bear edition with least energy and toxic emissions possible. All workers involved had reasonable employment rights and conditions. We have used 100% cotton fibres and lots of creativity to bring the Augmented Reality storytelling to your home.

Please make sure to use the product until the natural end of its life, and to pass it on, if you don't find it useful anymore. Wash it only when necessary, at low temperatures and using eco-detergents. Please hang-dry Textales and avoid ironing where possible. Repair if needed and make sure to bring it to a textile-recycling unit in the end of its life" (Textales care label).

Since Textales Sunny Sunday edition is a collaborative creation of several people, it allows creativity to step into daily life of more people. It inspires making rather than consuming. The process of making and sharing the project has also created several moments to share insights under a larger umbrella regarding issues the research project is dealing with. In its own way, the project is raising awareness of the textile industry's societal problems one person at a time.

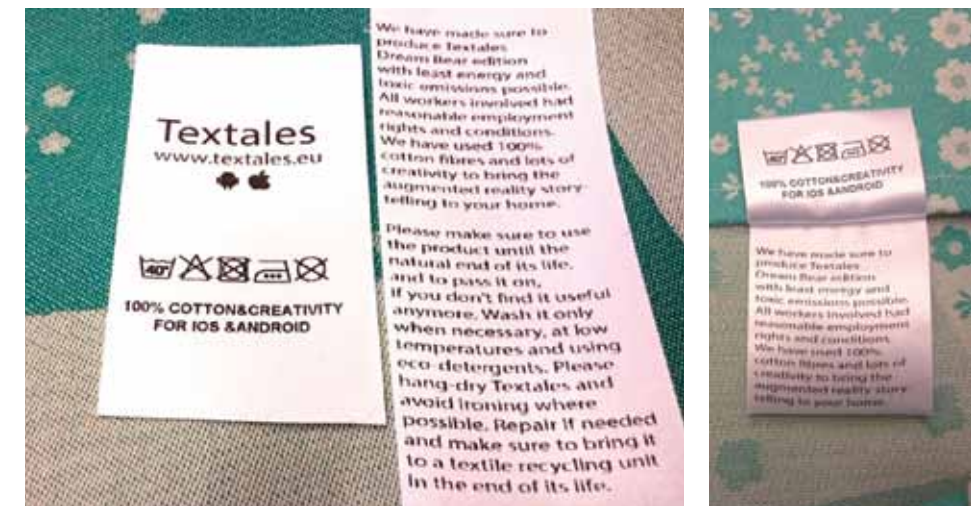


Figure 61 Labels inside Textales Dream Bear edition inform the users how to take care of the duvet cover in symbols and text.

Societal Responsibility makes sure materials and people who are part of the production process are treated fairly.

Definition

CQ7: FAMILY CONNECTION

In traditional crafts

Kabun pointed out that families were closely connected because of time specifics. People had no other choice than living very closely together in small spaces. According to her, "videviku tunni pidamine," [an hour for sunset], was there to share all the stories with the family.

In Textales

For connecting families through the shared stories, the craft experts saw the textile in the Textales concept as the interaction mediator. They valued the role of Textales in creating family time. They saw the application as a trigger to bring that shared time forward. Ahven pointed out Textales as “a tool for communication, to create quality time in the family.”

Reflection of the designer-researcher

Crafting together in the family while sharing stories of the day that has just passed used to be daily practise when families lived closer together. The way that families are scattered between different houses, towns, countries and continents today limits possible interaction. Allowing digital technology to merge with warm and soft textile in the context of family stories opens up new ways of supporting emotional connection within or between families (Figure 62). For example, in future developments the fairy-tale could be told to a child in Sweden via the tablet app by her grandparents in Brazil.



Figure 62 When exploring the story of Textales Dream Bear edition, the users found creative ways to become part of the story.

In Textales Dream Bear edition, playing with the stories and the textile creates the family together time (Figure 63). This allows the values and moments to be shared. As the future developments of the application could function over distance, the story sharing could be extended to family physically further away. Through that process, the hour for sunset could be regained as a family time independent of the geographical locations of the people.



Figure 63 The family connects in different levels while using Textales Dream Bear edition creatively.

Crafting together, or at least the same item, creates the shared family time in Textales Sunny Sunday edition. Family in this case is seen as the chosen family – friends, group of colleagues, or other parties. Working on a mutual goal naturally leads people to share stories. Textales Sunny Sunday also mediates communication over time. People in the party might change, join, or leave. It is interesting to know different perspectives of the stories that have been shared in the space.

Family Connection values the shared time within groups or families while making and creating together.

Definition

CQ8: OPEN SOURCE COMMUNITY

In traditional crafts

For the open source community, the experts pointed out the pace of change to be the difference. For the Muhu skirt to change from red to yellow, the pace of change was very slow. Changing digital characters in the tablet application of Textales takes only minutes. The craft experts also pointed out how the same symbol could have meant a different thing in the north and south of a country. Sometimes a symbol was borrowed from another region; however the meaning adapted to it came from the local context.

In Textales

Compared to traditional crafts, digital applications can change at a faster pace. However there is also a difference in the speed of the change depending on whether the user is crafting a patch, modelling a 3D character, downloading a premade model, or attaching a photo. The craft experts appreciate that the project involves technical solutions while remaining easy to use.

Reflection of the designer-researcher

Today textile design and its development have taken great leaps. The details and complexities achievable by modern machines are impressive. It has decreased some of the openness and personalisation possibilities for the end user though. It is a step further out of our basic skill-range. Therefore, crafting fabrics is in a way limited to the closed group of textile designers and makers working professionally in the area. On the other hand, at the beginning of the 21st century, people are quite familiar with digital tools. Children start working with screens and programming languages and tools early, in their first years at school. Having said that, they can easily navigate between digital content: create and modify 3D items and stories and develop applications. The potential to change the digital content appearing on the textile are wide, especially if the application could be considered an open source platform.

In Textales Dream Bear edition, the community of creators has access to information and the possibility of developing the project in a certain direction. At the time of developing it, the collaboration partners did not see the feasibility of making the application into a platform, where users could add their own characters and stories. This limitation was the main trigger to start working on Sunny Sunday edition in parallel to the Dream Bear one.

In the Textales Sunny Sunday edition, objects can be added both physically and/or digitally by the end user. A patch or a shape, a stitch or a button, a photo or a print can be added at any point in time to the textile canvas. This physical add-on can become a marker in the Textales Sunny Sunday edition, and easily connected to a new digital content as well. The digital content can also be updated with new 3D models, photos, videos, sounds, etc. later on.

Definition **Open Source Community is about creative use of global resources locally. It is about an item becoming a platform for shared making.**

CQ9: EVOLUTION IN TIME

In traditional crafts

The experts discussed crafts evolution in time, taking two possible directions: 1) towards industrial technology, and therefore crafts getting more simplified; 2) towards complexity or style of the pattern, and therefore to develop the craft further. They pointed out the importance of having a distinction between craft, handmade, and piecework, since all of them are made by hands, however with a completely different focus and meaning. The experts pointed out that if the craft items get simplified the feeling they embed and carry gets degraded. Ethnographic patterns in another context (for example under a dictatorship) get a different meaning; therefore succeeding generations always need new symbols.

In Textales

The experts acknowledged the Textales Sunny Sunday edition being community based and allowing open software development and sharing. More importantly, they found the skill of telling the story as the most essential property for both of the projects.

Reflection of the designer-researcher

In the Textales Dream Bear edition, the evolution in time is limited by the commercial input and the interest of someone in continuing to develop it. The application is closed and professionally developed by one of the partners in the project; the professional illustrator has completed the story. To bring changes and new aspects into the story and concept is up to the development team. The platforms it works on is limited to iOS and Android. However, the further developments that are possible could lead towards an interesting service: new stories when kids grow or just want to change them, new characters in existing stories to bring new insights, or for special occasions, new actions for the existing characters, new adventures (side stories) into existing stories. The professional approach and dedication to the project allows it to be developed towards style and complexity while being an industrial process.

In the Textales Sunny Sunday edition the evolution in time is one of the key elements. It uses only open source software and is therefore always open for modifications, add-ons and other suggestions that users can implement without approaching any specific developer. It has the potential to be community based for both new developments in software and stories that are shared. Both the content and the software could continually change and evolve over time, catching up to modern ways of living, tools, and contexts. In the open source mode, the project could take several diverse directions and excel in applications that cannot be foreseen at the moment, being limited by our current way of seeing the world.

Definition **Evolution in Time is linked to the constantly changing world. It is about allowing the items to change in time with people.**

This chapter gave an overview of how I developed the craft qualities in smart textile services in the RtD process, alternating between design and research activities. The craft qualities identified by craft experts in traditional craft examples and the smart textile examples QR-coded Embroidery and Bedtime Stories were presented. The project bringing textiles and Augmented Reality together through fairy tales was developed further with the first version of craft qualities. I re-defined my understanding of the craft qualities through the craft expert interviews and re-designing the next iteration of Digital Stories on Textile, Textales. The redefined understanding of the craft qualities was brought back to the craft experts. The reflection on the craft qualities through the way they appear in traditional crafts, such as Muhu skirt, Textales Dream Bear and Sunny Sunday editions was presented as the second version of the craft qualities.

The identified nine craft qualities are: Embedded Meaning, Material as a Medium, Hidden Stories, Heritage and Tradition, Touch and Feel, Societal Responsibility, Family Connection, Open Source Community, Evolution in Time. Embedded Meaning is “coded” to the craft object by the maker. It could be either very personal and unique or wide-known to distinguish a particular group. Textales has the extra “coded” layer that only becomes visible through technology. Material as a Medium communicates the meaning that the natural and man-made environment has embedded into it. Through Textales, the interaction between the cloth and the tablet/smartphone communicates the story it has been programmed to show. Hidden Stories is about the narratives attached to the craft items. They can be carried in people’s imagination, as in the case of folk garments, or in technology, as in the case of Textales. Heritage and Tradition are brought to later generations via shared knowledge and stories. Crafts were strictly part of common knowledge. Through the contemporary versions of traditional fairy tales, long lasting ideas can be communicated in a modern way. Touch and Feel of craft objects is appreciated while they are being made as well as when using the items. In Textales, touch is used as the main inspiration and trigger for interaction in hybrid storytelling. Societal Responsibility has to be at a high level in traditional crafts as well as in new technological developments. Environmental, societal, and economic sustainability aspects have to be considered when bringing a new concept into the world. Family Connection is appreciated as a value and enriched through spending active time together. It is about crafting together for a wedding dowry and creating new storytelling experiences with Textales. The Open Source Community appreciates sharing and building on each other’s knowledge within a community. In Textales, the openness is explored by allowing the textile canvas to become a platform for multiple stories by various makers. Evolution in Time enables the craft to grow instead of stagnating, and allows the stories in Textales to change together with the family and its different phases.

While developing the craft qualities and the accompanying projects, some questions arose. It is possible and rather accessible to learn and adapt traditional craft techniques to new materials, machines, and environments. However, how do we translate the meaning and the experience from another value system? Can I experience the life in a certain time in a particular situation, through touching the same tools and patterns? Can the craftsmen touch each other through a shared pattern? How about the wearers? Can tacit knowledge be transferred between different times? Can meaning be transferred? Can experience be shared? How would the industry react to craft qualities? Would they adapt something embedded with meaning? What would be important for them to keep in the concept? What would they change, trying to be more efficient? How would industry adapt qualities crafted into a smart textile product or service? Would any of it remain or perhaps create an extra value?



CHAPTER 5

This chapter analyses environmental, societal and economic sustainability notions in the context of smart textiles services. The list and descriptions of sustainability qualities, formed by two sequences of expert reviews, are presented for the future development of sustainable smart textile services. The chapter shows how sustainability qualities, such as Minimising Consumption, Controlling Energy and Chemical Use, Developing Constantly, Caring for Longevity, Supporting Meaning Creation, Updating the Product, Empowering Positive Emotions and Building Relationships are discovered based on the smart textile examples Bedtime Stories (2.1.2), Vibe-ing (2.2.3.1) and CHACUN(E) (2.3.1), and evaluated in the context of Textales (2.1.3). The insights can be used for the future development of sustainable smart textile services.

BACKGROUND 5.1

SUSTAINABILITY CHALLENGES 5.1.1

The development of smart textile products, which lie at the intersection of fashion and technology, raises additional sustainability challenges for the traditional garment and electronics industries that are driven by fashion and generate several environmental and societal problems. However, smart textiles offer novel opportunities for the development of unique services that would generate extra value and sustain meaning in a societal and economic context. For example, leasing, personalisation, and care directions are interesting to explore.

Köhler (2013) identifies two major environmental risks within the development of smart textiles: increasing consumption of scarce raw materials combined with increasing amounts of difficult-to-recycle electronic waste. These risks, in combination with the looks and trends driven textile and fashion industry which promotes quick product turnovers and fast-fashion, create concerns not only for environmental but also for societal and economic sustainability (Peake, 2012). However, the combination of textiles and technology also opens up opportunities, especially for societal sustainability, which are mainly concerned with providing a good quality of life for individuals and communities; for example, services for transferring heritage and traditions, remote health care and personalisation. The sustainability qualities reach beyond the material, into the production, use, and result-oriented sustainability aspects for textile products. Throughout the process the smart textiles move towards product service systems (PSS), which is pointed out as a sustainable direction for textile products by Armstrong et al. (2014): “Clothing bundled with services might provide an opportunity for the industry to offer product quality, durability and extended use time, increasing overall satisfaction. At its best PSS thinking can offer dematerialization possibilities for clothing consumption and opportunities to close material loops” (p. 39).

*Consumption
of scarce raw
materials*

*Difficult-
to-recycle
electronic
waste*

To understand how the service could support smart textiles to become more sustainable, I approach the topic from the environmental, societal, and economic point of views often seen as the main pillars to talk about sustainability (Adams, 2006; Lumsden, 2003). The three views are so interconnected that it is difficult to approach them separately. The damaging influence of

environmental and social problems caused by the whole life cycle of a textile product is not going to be solved at the material level. Sustainability thinking needs to go beyond environmental issues (Gwilt & Rissanen, 2011) to social and economic ideas, which are strongly present in our lives. The textile and clothing production supply chain with the whole life cycle of the garment, from creation to disposal, needs to be redefined. To drive that change, a garment has to reflect the actual worth and value that has been put into it. According to McQuillan (2011), “The future of the fashion industry cannot lie in organic garments within the traditional fashion system, whose production still generates hundreds of thousands of tonnes of textile waste, garments that then get transported around the world thousands of kilometers only to be discarded into landfill at the end of the season. While organic fibers are a part of the solution, we need to remake the way we make and consume clothes” (p. 96).

Holistic sustainability, which emphasises responsibility over the environmental, societal and economic sustainability approach, challenges the current notion of progress oriented to (economic) growth (Meadows et al., 1972). Growth as the essential pillar of the present economy cannot be tackled without talking about reducing the amount of products and waste produced. The latter requires a shift from a linear economy to a circular economy through increasing intrinsic durability of products and carefully maintaining them (Cooper, 2005). To achieve slower consumption through increased product life spans, Cooper (2005) suggests combining both efficiency – that is more productive use of materials and energy – and sufficiency to reduce the throughput of products and materials. “Meanwhile a shift to more highly skilled, craft-based production methods and increased repair and maintenance work would provide employment opportunities to offset the effect of reduced demand for new products” (p. 55). One way to look into slower consumption is through meaning creation. Niinimäki (2011) suggests connecting the design outcome deeply with a consumer’s emotions, identity construction, aesthetic needs, and personal memories, that is, values and lifestyle. Then, she suggests, the design process could achieve a deep product satisfaction and product attachment. This is an opportunity to extend the life cycle of the products potentially achieved by implementing meaningful services in the textile field.

Towards holistic sustainability

When offering his critique of industrial infrastructure, McDonough (2002, p. 17) compares it metaphorically to the Titanic, like something trying to work by its rules and not by those of nature. Talking about the artificially maintained system that the Industrial Revolution created, he brings out the contradiction that “While the economic payoff immediately rises, the overall quality of every aspect of this system is actually in decline” (p. 35). On the brighter side, McDonough offers a thought experiment: “Imagine a building like a tree, a city like a forest” (p. 139). It is not about neglecting technology and going back 200 years and more in the way people do things. It is about designing systems in a way they can flourish without harming other aspects of life. Sustainable business research leans towards holistic sustainability. Bocken et al. (2015b) describe “Sustainable business thinking” as a holistic approach, that can be used when thinking about business that seeks to integrate consideration of the three dimensions of sustainability – societal, environmental and economic – in a manner that balances or aligns value creation for all stakeholders including the environment and society at all levels and through all activities of the business. Bocken et al. (2015b) specifically note that collaboration across a wider set of stakeholders in the industrial system is necessary to deliver sustainability.

Services for sustainability in textiles

To support sustainability as a fundamental cultural idea, the World Conservation Union suggests looking at the culture of consumerism and redefining the economy in a way that people can get more yet consume less. One idea they suggest for this is an economy of services rather than

objects that would generate value without generating waste or unnecessary physical or energy throughput (Adams, 2006).

Product Service Systems are seen as opportunities towards more sustainable consumption specifically in the textile field. According to Niinimäki (2012), the most promising sustainable design strategy is the combination of product design with service elements. It is not a new approach in textiles. Hospital and hotel sheets have a long history of being rented by a service provider to the facility. The third party cares for, cleans, mends and replaces if necessary the bed linen. The same is true for work wear that needs a particular type of cleaning and machinery. Lindström, for example, provides the use of work wear, restaurant textiles, shop towels, mats, personal protective equipment and cotton towels for hygiene among other services for their clients. The service typically includes needs assessment, recommended solution, acquisition and delivery of products tailored for the customer, consultation visit, textile wash and maintenance, optimising product quality and volume, disposal and recycling, regular communications and customer service (Lindström, 2012).

Emerging examples in the apparel field include the traditional leasing model applied in new contexts. Mud Jeans (2014) leases jeans, hoodies, and second-hand clothes. Nopsa Fashion Library (Engeström & Jokinen, 2011) leases new and vintage Finnish clothing design. Also, personalisation in a new way is applied through new emerging business models. Constrvct (Yoneda, 2012) turns any photo into custom clothing. Sangar (2014) adjusts the shirt’s size, pattern and colour, fit and back type, buttons, collar type, edges, cuffs, pockets, etc. as ordered, to deliver a fully made-to-measure shirt. The 10-year hoodie is a great example of durability (warranty) and crowdfunding principles. Flint and Tinder (2014) launched a project on the crowd-funding platform Kickstarter, promising to deliver comfortable, durable sweatshirts with a guarantee of 10 years (for free mending). They promote the mindset that not everything needs to be disposable. Flint and Tinder have their sweatshirts made entirely in America, where they are selling them. Traditional textile product longevity can be extended by repair, redesign, customisation, participatory design, DIY, consultancy and renting services (Armstrong et al., 2014). Would the interactive and dynamic properties of smart textiles allow new kinds of services to emerge that could also extend the longevity of textile items?

THE STUDY IN GENERAL 5.1.2

At the beginning of the study about sustainability qualities (Figure 64), I, as a designer-researcher, formed my initial understanding of sustainability in the context of smart textiles. This understanding was broadened through semi-structured interviews with three sustainability experts focusing on Bedtime Stories, Vibe-ing and CHACUN(E) projects. The gathered information became the basis to revise my understanding of environmental, societal and economic sustainability in the smart textile services context. The sustainability qualities were drafted according to my revised understanding and assigned with a label and a meaning. The results were brought back to the sustainability experts for the review of the first version of sustainability qualities to deepen the understanding for the second version of sustainability qualities. The review discussion focused on seeking the sustainability qualities in the re-design of Bedtime Stories project – Textales Dream Bear and Sunny Sunday editions. Reflecting on the comments received from the sustainability experts, experience gained from working with the material, and feedback from the community, I deepened and made concrete the second version of sustainability qualities.

SUSTAINABILITY QUALITIES

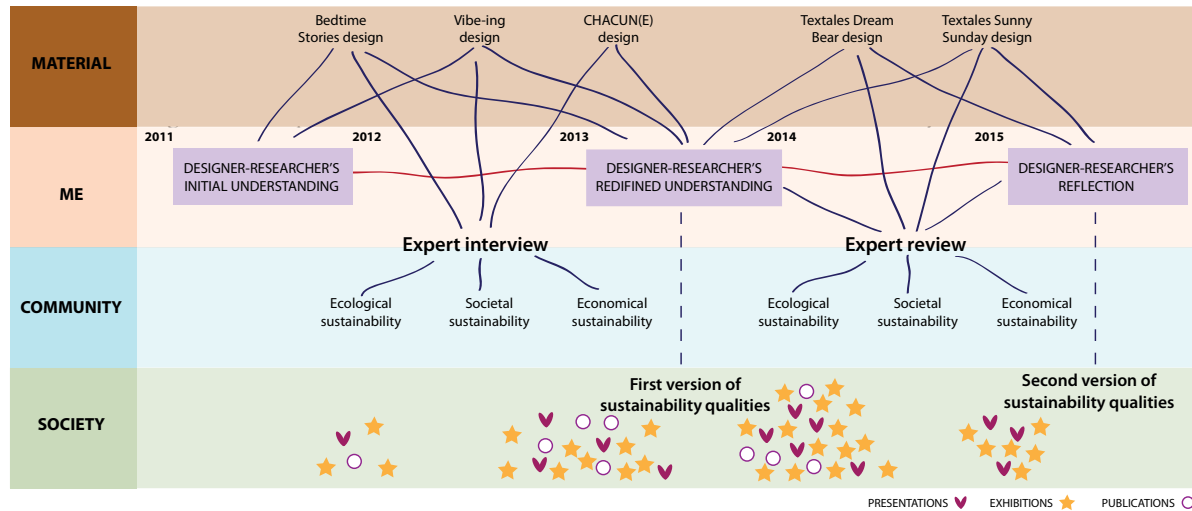


Figure 64 The RtD process in discovering and refining sustainability qualities in smart textile services.

5.2 SUSTAINABILITY QUALITIES IN BEDTIME STORIES, VIBE-ING, CHACUN(E)

To translate my personal understanding about sustainability in the context of clothing from the material to the community and the outside world, I looked into the possibilities and challenges that sustainability poses for the field of smart textiles. My understanding was confronted in the form of three smart textile prototypes, Bedtime Stories Little Red Riding Hood (2.1.2.1), Vibe-ing (2.2.3.1) and CHACUN(E) (2.3.1), with the community of sustainability experts.

5.2.1 METHODS FOR COLLECTING AND HANDLING DATA

The collected information became the basis to revise my initial understanding of sustainability qualities in the smart textile services context. Based on this redefined understanding, I drafted up the first version of sustainability qualities and associated them with a meaning and a label.

People knowledgeable in sustainability were approached for the expert interviews. The aim was to find out their views on risks and challenges for smart textile services, in the scope of environmental, societal, and economic sustainability. The experts reviewed the three projects, Bedtime Stories Little Red Riding Hood, Vibe-ing and CHACUN(E), to understand the type of challenges particular to the smart textile area. Three projects with different levels of integration of textile and technology were chosen from the Portfolio (Chapter 2) to reflect on the questions they raise about sustainability. Bedtime Stories Little Red Riding Hood, a duvet cover with the functionality adapted by technology, triggers parents to share stories with their children. It is envisioned for use in a home context. Vibe-ing, a demonstrator for a sweater self-care tool with integrated technological components that allow therapists to send care programs over distance to their patients, is used in an exhibition context, to start the conversation between the interested parties. CHACUN(E), a costume made by using a yarn combined with thermochromic pigments, inspires a dancer to perform and communicate her values to the audience. It is used

in a stage performance context. Three experts whose expertise lies in environmental, societal and economic sustainability were invited to share their knowledge in the context of smart textile services. Dr. Andreas R. Köhler (2013) has a background in environmental risk prevention and development of emerging smart textiles technology. Professor Alastair Fuad-Luke (2009) focuses on positive societal impacts contributing to the international debate about how design can encourage co-futuring. Dr. Mika Kuisma's research is focusing on corporate responsibility performance and impact assessment, as well as innovative and eco-efficient business models and practises (Halme, Anttonen, Kuisma, Kontoniemi, & Heino, 2007).

Similar to the research into craft qualities (Chapter 4), the experts were involved through informal conversations, semi-structured interviews, and e-mail exchanges. The experts were supposed to feel free to share their insights in a most appropriate form for them. E-mail communication was used to confirm the understanding I got from the interviews. During the interviews, I introduced the three smart textile projects, Bedtime Stories Little Red Riding Hood, Vibe-ing and CHACUN(E), to the experts, and asked them to react to the concepts from their expertise. Most interview questions were open-ended, and each conversation was allowed to take a different course depending on the interest of each participant. However, they all were asked to describe what they found interesting and potentially harmful for sustainability in the specific cases. All interviews lasted approximately one hour. For data capture, all interviews were recorded and transcribed. The notes were transferred into a table (Table 3) showing the reactions of sustainability experts during the interviews, and were later attributed with a meaning and a label representing each quality.

RESULTS FROM THE SUSTAINABILITY QUALITIES INTERVIEW

The sustainability experts shared their opinion about the aspects of environmental, societal and economic sustainability they saw in Bedtime Stories Little Red Riding Hood (within this chapter in short Bedtime Stories), Vibe-ing, and CHACUN(E) projects in Table 3. Similar topics have been grouped to achieve condensed meaning units and attributed with a label. The label becomes the name of the sustainability quality.

For example, when talking about sustainability challenges and opportunities in Bedtime Stories, Köhler stated: "The main environmental impact in the combined product is with the iPad. It involves a combination of scarce and toxic materials, energy consumption to produce and to run it, and e-waste at the end of life. Such equipment has a relatively heavy environmental burden over the whole life cycle." Fuad-Luke posed a question: "Creating meaning is the only way to change societal behaviour, and who is better to create meaning than the people themselves?" However, Kuisma pointed out the challenge: "Even large corporations have difficulties measuring the impact of material use on the overall sustainability" (row 1, column 1). Köhler comments on Vibe-ing: "Sooner or later it will be put into the garbage and it becomes part of normal waste treatment, being a hazard waste. Electronic textiles are difficult to recycle and therefore a great problem for waste treatment" (row 1, column 2). For the sustainability of CHACUN(E), Köhler states that to make a Life Cycle Assessment for a unique product that is not planned to be produced is an academic exercise. "Compared to all the gadgets that have mass production impact, this is practically not relevant" he says (row 1, column 3). I summarised the previous information: "The application has to support all major operating systems (OS) running on the major popular smart devices, to avoid having to buy new devices. The textile should be open-generic to new stories" (row 1, column 4). The label applied to the quality is "Minimising Consumption" (row 1, column 5).

SUSTAINABILITY IN BEDTIME STORIES	SUSTAINABILITY IN VIBE-ING	SUSTAINABILITY IN CHACUN(E)	MEANING	LABEL
The main environmental impact in the combined product is with the iPad. It involves a combination of scarce and toxic materials, energy consumption to produce and to run it, and e-waste at the end of life. Such equipment has a relatively heavy environmental burden over the whole life cycle. (Köhler) Creating meaning is the only way to change societal behaviour, and who is better to create meaning than the people themselves. (Fuad-Luke) Even large corporations have difficulties measuring the impact of material use on the overall sustainability. (Kuisma)	Sooner or later it will be put into the garbage and it becomes part of normal waste treatment, being a hazard waste. Electronic textiles are difficult to recycle and therefore a great problem for waste treatment. (Köhler)	It's an extremely academic exercise of making LCA for a unique single product. as it contains half a gram electronics and thermochromics. Compared to all the gadgets that have mass production impact, this is practically not relevant. (Köhler)	The application has to support all major OS systems running on the main popular smart devices, to avoid buying new devices. The textile should be open-generic to new stories.	Minimising Consumption
It's possible to argue that downloading the application to the device consumes less online time when compared with streaming video or internet browsing over the same amount of time. (Köhler)		<div style="border: 1px solid black; padding: 5px;"> <p>If there is something to look into, that would be the energy consumption for the heating wires. If the garment uses body heat, that is not an issue but with heating wire, it consumes energy. To produce heat consumes relatively more battery power (as compared to logic devices). And it's questionable if the use of heat just for changing color is a smart way of using the energy. (Köhler) It is not extremely unusual chemistry, it is not immediately toxic, but it contains a mix of special organic chemicals (Leuco dye or liquid crystals). Some thermochromic inks (not all) contain Bisphenol A (BPA). The chemical is also in widely used in thermoplastics (as a softener). In the long run it has hormone toxic effects. If aquatic animals (and also humans) are exposed to small concentrations over a long time, the BPA camouflages biogenic hormones, which can inflict infertility and other biologic effects (e.g., allergies). If you take it into the body over longer time it can create hormone effects. Most organic chemicals in inks are quite bio-persistent, that means, they remain in the environment and organisms can take them up. There may be accumulation effects in the food chain so that the animal (or human) at the end of the food chain is exposed to quite high concentrations. (Köhler)</p> </div>	The application needs to keep working locally on the user's device to minimize online time for less energy use. The materials for the textile need to be chosen carefully considering their environmental impact.	Controlling Energy and Chemical Use
The possibility to update the stories on the blanket can be an aspect to extend the lifetime of the textile and iPad combination. Lifetime of the product depends mostly on the iPad. Bed linen can be used for a longer period of time. (Köhler)	If Vibe-ing reduces medical attention in a successful way, then we lower the amount of traffic, hospital time, other pain related issues (medicines, painkillers), producing medicine is quite a relevant environmental burden. (Köhler)		The application needs to be compatible with newer devices constantly coming out.	Developing Constantly
As known from the textile industry, the growing of cotton fiber has its problems within the ecosphere. It involves extensive use of scarce fresh water (irrigation) and power consumption for pumping water which contribute to the climate change. The wide use of fertilizers and pesticides leads to chemical pollution alongside with the dyeing and bleaching of the spun fibers. Typical aspects throughout the production chain, such as weaving, sewing, ironing, are not missing from the impact picture as well. (Köhler)	Already pure textile products are difficult to recycle because of the mixture of fibers. More difficult than the recycling is the take-back & collection & sorting of post-consumer clothing. They might have another life as second-hand garments, but in the end it will be disposed with batteries, etc. (Köhler)		The textile has to live up to its potential (live long), which means it needs to be taken proper care of.	Caring for Longevity
Sustainability is a societal journey, it's a values conversation, it's about sustaining meaning that we value. Textiles are only smart if they sustain meaning. Reading of the patterns and the value you give to them, building a new story through the smart textiles. (Fuad-Luke) Creating meaning is the only way to change societal behaviour, and who is better to create meaning than the people itself; It's all about the story or the meaning of the story. (Kuisma)	Can clothes make us better? Emotional wellbeing from a hugshirt? New roles to our clothes, new functions..that leads to new stories, new meaning, something else new ? It's needed to find out that new In the context of smart textiles and clothing. What <i>new new new</i> can the PSS deliver and how does it relate to the customer? (Fuad-Luke)	It's all about the story or the meaning of the story. Individual search of meaning- that's why maker culture is popular, but what's it for, what's the meaning? (Fuad-Luke)	The user must be able to create new stories; the user must be able to develop and share their stories.	Supporting Meaning Creation
If you know who made the story, then it's valuable. It's important who makes the stories as well as what the stories are. (Fuad-Luke) Well-being of the people involved in making and distributing and using the product. (Kuisma)	2 percent of the material impact in the world is the clothes.. And 98 percent of how we feel. (Fuad-Luke) It's most important to consider the needs of the person that arise from the mental, spiritual etc issues. (Kuisma)	It could be an indicator color. (Kuisma)	The application needs to develop over time to adapt the changing needs of the user.	Updating the Product
It's a worry that technology drives the story and not the meaning. And we are in a desperate search for meaning... Plenty of information but not much meaning. (Fuad-Luke)			The application has to be easy to use, the technology must allow the freedom to create the stories freely, with no major limits.	Empowering Positive Emotions
Used in families so it brings in social living in families. (Kuisma)			The character of the story creation and sharing has to support interaction within the families.	Building Relationships

Table 3 Comments from sustainability experts about the opportunities and challenges in the smart textile projects.

The next part of this chapter analyses the expert input along the lines of environmental, societal, and economic sustainability and my redefined understanding of the sustainability in the three designs. The main themes emerging from the environmental sustainability perspective are: materials and waste generation and treatment, people's consumption habits having the leading role in the waste issue, energy use during production and use of the products and chemical use mostly in the production phase. The main themes emerging from the societal sustainability perspective are story and personalisation creating meaning for the user. Also some insights from economic sustainability support personalisation as a firm pillar to start with the story building.

5.2.3 SUSTAINABILITY QUALITIES IN SEPARATED SMART TEXTILES: BEDTIME STORIES LITTLE RED RIDING HOOD

Köhler pointed out the main material impact in Bedtime Stories arising from use of the iPad. "The iPad, in fact, has the main environmental impact of the combined product. It involves a combination of scarce and toxic materials, energy consumption to produce and to run it, e-waste at the end of life. Such equipment has a relatively heavy environmental burden over the whole life cycle" (Interview with Köhler, 13.11.2013). Also the lifetime of the combined products mostly depends on the iPad, as bed linen typically tends to last longer than technical gadgets. The iPad's impact depends on whether the family already owns an iPad, or the application compels them to get one.

About energy use, Köhler stated, "The only actual added direct impact to the environmental impact in The Bedtime Stories lifecycle is the exact extra use time of the iPad that is added by the Augmented Reality fairy tale application" (Interview with Köhler, 13.11.2013). He mentioned that using the application offline saves some energy compared to the same usage time over online streaming. Another high-energy impact comes from washing and drying the duvet cover. However, that is not different from any other bed linen that also needs to be taken care of (Interview with Köhler, 13.11.2013).

Fuad-Luke stated that creating meaning is the only way to change societal behavior, and people themselves are the best agents to do it. Sustainability he saw as a societal journey – a valued conversation, which is about sustaining meaning that people value. Therefore, he saw Bedtime Stories' intelligence in the meaning sustaining, and in the new story building through smart textiles (Interview with Fuad-Luke, 17.12.2013). With regard to personalisation, Fuad-Luke pointed out that the author of the story was as important as the story itself. He expressed worry about the technology influencing the story. He warned of the situation where technology instead of meaning would drive the story. "And we are in a desperate search for meaning. Plenty of information but not much meaning" (Interview with Fuad-Luke, 17.12.2013). Therefore, it's important that people can build personal stories with Bedtime Stories.

Kuisma mentioned happiness as a good indicator for economic sustainability alongside the belief that economic aspects needed to serve societal ones. He noted that Bedtime Stories is used in families and therefore brings social living into families. He also stressed the importance of the opinion of the user and how the user's needs, concerns, and problems should be taken into account (Interview with Kuisma, 20.12.2013).

Opportunities for sustainable smart textile service

To minimise the environmental sustainability burden resulting from the use of Bedtime Stories, both its digital and physical textile elements need to be considered. After the re-design, the application should support the primary OS systems running on popular smart devices. The family has to be able to run the Augmented Reality fairytale application on their existing device. The application needs to keep working locally on the user's device to minimise the online time for lower energy consumption. The development team needs to choose the materials for the textile considering their environmental impact.

Critical aspects to take into account for the re-design of the Bedtime Stories product and service:

- 1 The textile has to live up to its potential (longevity). This means the textile has to be maintained properly. One solution to achieve professional care taking for the textile would be to keep the ownership of the textile with the service provider. The company leasing Bedtime Stories should arrange knowledgeable and skilled cleaning and repair service.
- 2 The application needs to be compatible with newer devices that come to the market.
- 3 The application must keep developing over time to adapt to the changing needs of the user.
- 4 The user has to be able to create new stories.
- 5 The user must be able to change and share their stories.
- 6 The technology should allow freedom to users to create stories freely, with no unreasonable limits.
- 7 The nature of the story creation and sharing has to support interaction within the families.

SUSTAINABILITY QUALITIES IN INTEGRATED SMART TEXTILES: VIBE-ING 5.2.4

In the case of Vibe-ing, Köhler emphasised the importance of looking at the whole life cycle. "In terms of the Life Cycle Assessment (LCA) the whole cradle to grave (disposal phase) should be considered, among which the materials and production of these materials used (cotton, wool, steel fibers, coated fibers, electronic fibers, silver coated fibers, microchips, vibration motors (metals, plastics), batteries etc.)" (Interview with Köhler, 13.11.2013). He added that electronic textiles are difficult to recycle and, therefore, a great problem for waste treatment. Even pure textile products are difficult to recycle because of the mixture of fibers. More challenging than the recycling, is the take-back, collection, and sorting of post-consumer clothing. It might have another life as second-hand garments, but in the end it will be disposed of with batteries, etc. (Interview with Köhler, 13.11.2013). Combining the common issues from the textile field (water, energy use, pesticides) with the problems arising from the electronics production (toxic waste, scarce materials) and disposal, it is clear that it is a very particular combination, which has a lot to do with the habits and mindset of the user. Moreover, Köhler stated, "The energy consumption of production and using Vibe-ing should be considered" (Interview with Köhler, 13.11.2013).

Fuad-Luke posed a question about Vibe-ing, whether a garment could support personal well-being, and appreciated the unique customisation the garment provides for the user. He asked whether clothes could make us better and about new roles for the clothing. What new functions, stories, or meanings could the garments carry (Interview with Fuad-Luke, 17.12.2013)?

Opportunities for sustainable smart textile service

For Vibe-ing to be environmentally, societally, and economically more sustainable, the electronic and textile materials need to be selected carefully considering their environmental impact. Also, the energy consumption in the use phase requires closer attention, as well as the notion of using it efficiently (turn the device off when inactive, possibility to generate energy from the use itself). The motor boards need to be compatible with the wide range and improving technology.

Important aspects of the service to be implemented for Vibe-ing are:

- 1 The product has to be kept in use as long as possible to gain the maximum value of the materials used. It needs special care due to the combined textiles and electronics. Leasing and repurposing the garment when necessary could achieve that.
- 2 The service needs to support emotional well-being.
- 3 The service needs to take into account inclusive design aspects.

5.2.5 SUSTAINABILITY QUALITIES IN COMBINED SMART TEXTILES: CHACUN(E)

In case of CHACUN(E), according to Köhler, the uniqueness of the product makes its eco-footprint negligible. Producing individual one-off or small quantity pieces is irrelevant in the context of mass production in both the electronics and textile fields. Regarding the idea to develop CHACUN(E) further to react to the heat of conductive threads, Köhler stated, “To produce heat consumes relatively much battery power (as compared to logic devices). And it’s questionable if the use of heat just for changing colour is a smart way of using the energy” (Interview with Köhler, 13.11.2013).

Chemical use is a widespread problem in textile production mainly due to the variety of pesticides used in cotton fields and the dyestuff handling in colouring the fabrics. Therefore, the materials and chemicals used in the product’s development, production and finishing phases require careful consideration. In CHACUN(E) in particular, the concern is about the thermo-sensitive pigments used in the yarns of the costume. According to Köhler however, “It is not extremely unusual chemistry, it is not immediately toxic, but it contains a mix of unique organic chemicals (Leuco dye or liquid crystals). Some thermochromic inks (not all) contain Bisphenol A (BPA). The chemical is also widely used in thermoplastics (as a softener). In the long run, it has hormone toxic effects” (Interview with Köhler, 13.11.2013).

Regarding the societal aspects of CHACUN(E), Fuad-Luke mentioned the importance of the individual story creation. He appreciated the personalised approach that allows each artist to use it in a way meaningful for his or her practise (Interview with Fuad-Luke, 17.12.2013).

Opportunities for sustainable smart textile service

For a performance costume, CHACUN(E), certain aspects are important to keep in mind for ensuring sustainability. Suggestions to use conductive yarns and batteries for the costume to change colour needs to be optimal and well thought through. The information about the chemical use needs to be open and available. The precautions in production/prototyping and use phase need to be taken seriously.

Important aspects of the service to be implemented for the Thermocraft include:

- 1 The costume has to be used to its full potential. It could serve as a performance piece first and keep spreading the concept of the act in exhibition or another type of presentation.
- 2 The uniqueness of the pieces and concept carries greatest value. They need to be enhanced and made explicit to the wearer and to the audience.
- 3 The story communicated through the performance should be clear and available in different formats for easy accessibility.

CONCLUSION FROM THE SUSTAINABILITY QUALITIES INTERVIEWS 5.2.6

According to the interview results and their analysis, major implications concerning the environmental sustainability of the smart textile products include material and waste treatments, consumption habits, energy use, and chemicals. The possibilities for smart textile services in societal sustainability lie in the personalisation and the storytelling aspects that have potential to extend the longevity of the products through making them more meaningful for the users. Economic sustainability relies significantly on the first two and could benefit from the implementation of service systems. Additionally to the traditional textile services, such as repair, renting, swapping, etc., the smart textiles’ interactive and dynamic properties allow services like story creation, personalisation, and support for well-being arise to contribute to the sustainable way of living. Of the three sustainability layers, the economic approach is the most challenging to discuss in the prototyping phase when the business model hasn’t been developed fully in the smart textile products context.

If smart textile product service systems provide personalised items on a lease basis, they take care of the durability and maintenance of the product, supporting slower consumption pace. By re-defining the garment (textile product) life cycle in such a way, the consumption of raw materials and generation of difficult to recycle waste would slow down as well. It is an opportunity to introduce the changing service models into smart textile product systems as they are still emerging. In this dissertation, the sustainability challenges act as opportunities for the service development. The proposed aspects for sustainable smart textile services are in principal about sustaining the meaning for the users. According to Fletcher (2008) the challenge of sustainability is to connect the fashion and textile identity with multiple layers of other human activity. Perhaps connecting the textile identity with multiple layers of human activity through environmental, societal, and economic sustainability could help to find meaningful ways towards sustainable smart textiles.

THE DESIGNER-RESEARCHER’S REDEFINED UNDERSTANDING OF SUSTAINABILITY QUALITIES 5.3

As my personal understanding of the sustainability qualities in smart textile services changed while designing the smart textile examples and conducting interviews with sustainability experts, my redefined understanding of the sustainability qualities is explained in this section. It captures the first version of sustainability qualities that acted as input for the re-design of Bedtime Stories Little Red Riding Hood (2.1.2.1) into Textales Dream Bear (2.1.3.1) and Sunny Sunday (2.1.3.2) editions. The first versions of the sustainability qualities as

my redefined understanding as the designer-researcher are presented in this section with a special focus on their meaning for the physical textile and the digital application of the Bedtime Stories Little Red Riding Hood project.

5.3.1 FIRST VERSION OF THE SUSTAINABILITY QUALITIES

A set of sustainability qualities was found as a result of the previously presented interviews with sustainability experts. Through the interviews with the sustainability experts, I found issues and opportunities for smart textiles in Bedtime Stories Little Red Riding Hood (2.1.2.1), Vibe-ing (2.2.3.1), and Thermocraft (2.3). The smart textile objects were presented to the experts and they were asked to comment on the ideas from environmental, societal, and economic point of views. What emerged is not a final and complete list of all the sustainability qualities nor are the mentioned qualities necessarily the most important ones. It is a set of qualities encountered within the smart textile services examples. The members of the project and interviewed sustainability experts identified that preliminary set of qualities. The first version of sustainability qualities was drafted based on the interviews, and this version expresses the redefined understanding of me as a designer-researcher. The sustainability qualities can inspire smart textile services to be designed from a sustainable starting point.

The identified eight sustainability qualities (SQ) are: Minimising Consumption, Controlling Energy and Chemical Use, Developing Constantly, Caring for Longevity, Supporting Meaning Creation, Updating the Product, Empowering Positive Emotions, and Building Relationships. These sustainability qualities served as inspiration for the re-design of the smart textile service project Bedtime Stories Little Red Riding Hood into Textales Dream Bear and Sunny Sunday editions.

The sustainability qualities are described focusing on the Bedtime Stories Little Red Riding Hood example. The sustainability of the duvet cover and the software application are viewed separately. The sustainability qualities present my redefined understanding of smart textiles' sustainability.

SQ1 Minimising Consumption is about slowing down the consumption of textile products by introducing smart textile services. Bedtime Stories Little Red Riding Hood's proposed concept of facilitating digital stories on the soft textile canvas could achieve that by encouraging people to keep their textile items for a longer time. On the other hand, lowering textile consumption should not raise the need for different technological gadgets. Therefore the software developers should assure multi-platform use for the next version of the project.

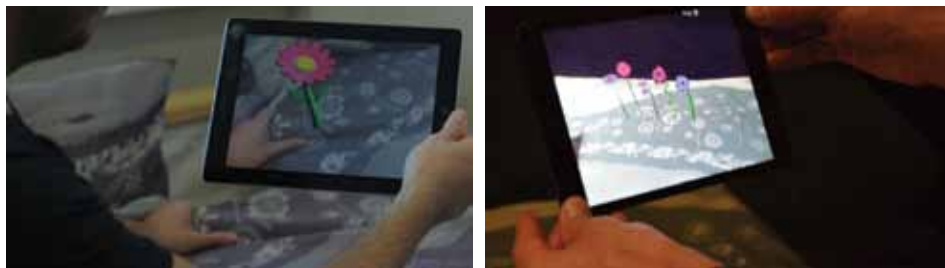


Figure 65 The different 3D flowers shown in Augmented Reality on the Bedtime Stories Little Red Riding Hood duvet cover have changed over time. However, the application can only be used on iPad.

SQ2 Controlling Energy and Chemical Use is about reducing the resources and toxins used in the process of producing and using the items through their lifetime. As for any textile product, the cloth used to prototype Bedtime Stories Little Red Riding Hood has been produced through the use of large amounts of water and power. The use of fertilisers, pesticides and chemical dyes has to be monitored. The user has to have sufficient information about maintaining the textile at home with minimal environmental impact. For the application, offline time is less energy consuming than online working time. Bedtime Stories Little Red Riding Hood was developed in an environmentally conscious factory (Figure 66) in the Netherlands.



Figure 66 Weaving facilities in Johan van den Acker Textielabriek.

SQ3 Developing Constantly is about the product being able to change in time. The textile can be used in several ways for different purposes. The application should be in continuous development and always be compatible with newer OS systems and devices. For example, one way to ensure technology is always up to date is to develop new stories continuously. Both the textile and the digital application of Bedtime Stories Little Red Riding Hood (Figure 67) changed and improved considerably over the development period.



Figure 67 The first prototype (textile and application) of Bedtime Stories Little Red Riding Hood.

SQ4 Caring for Longevity is about durability. The textile material needs to be maintained supporting its longevity. The user has to receive accurate and simple instructions on how to be able to care for the textile in a way that it remains beautiful for longer. Leasing models, as well as reusing/recycling ideas, could be beneficial to ensure the material is used to its full potential. Bedtime Stories Little Red Riding Hood story is woven into a high quality durable textile (Figure 68).

SQ2
Controlling
Energy

SQ3
Developing
Constantly

SQ4
Caring
for Longevity

Designed
from a
sustainable
starting point

SQ1
Minimising
Consumption



Figure 68 Textile roll with the fabric carrying Bedtime Stories Little Red Riding Hood story in different colours.

*SQ5
Supporting
Meaning
Creation*

SQ5 Supporting Meaning Creation is about triggering users' creativity. The textile is an open canvas to be modified as wished (stitch, cut, sew, glue, etc.). The application should allow creative freedom for the users. The end user should be able to create new stories, change them and share if fancied. In Bedtime Stories Little Red Riding Hood, the digital characters can mix with children's favorite physical toys (Figure 69).



Figure 69 A mother telling the Little Red Riding Hood story to children who participate in the story with their toys.

*SQ6 Up-
dating the
Product*

SQ6 Updating the Product is about the item's capacity to adapt to the changing needs of the user. The textile illustration and form are static, however they can be changed by cut and sew techniques. The adventures and characters appearing in the narrative can be changed digitally in the application. The development of the 3D flowers over time was shown in Figure 65. The pillows (Figure 70) were cut from the textile meant for the duvet cover. Similarly any other shape of item can be sewn. As long as the image recognition markers remain visible, the characters appear in the same way as on the duvet cover.

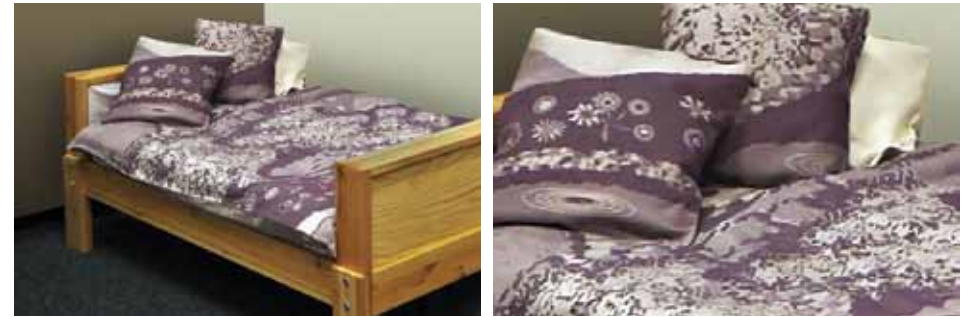


Figure 70 The Bedtime Stories Little Red Riding Hood duvet cover and pillows show during the Dutch Design Week.

SQ7 Empowering Positive Emotions is about usability. The textile has to be comfortable and beautiful. The application has to be easy and intuitive to use. The stories are more important than the technology. It should be possible to create new stories freely with no major limitations. For example, the positive emotions (Figure 71) are supported by a simple user interface of the Bedtime Stories Little Red Riding Hood.

*SQ7
Empower-
ing Positive
Emotions*



Figure 71 A mother sharing the Little Red Riding Hood story with her children.

SQ8 Building Relationships is about creating connections within families. The focus on Bedtime Stories Little Red Riding Hood is not to have an independent game for the children to play, but a communication means for the whole family. The textile provides a comfortable and safe environment to play with interactive digital characters in the application. The way the stories are created and shared needs to support interaction within families. For example, the mother always holds the iPad when children are exploring the story of Little Red Riding Hood (Figure 72).

*SQ8
Building
Relation-
ships*



Figure 72 The parent holding the iPad leaved children's hands free to explore the material and digital characters.

5.4 REDESIGN OF DIGITAL STORIES ON TEXTILE

This section is about re-design of the smart textile services example Bedtime Stories Little Red Riding Hood into Textales Dream Bear and Sunny Sunday editions. It shows how the first version of the sustainability qualities, presented in the previous section, influenced the re-design of the project. The previous design iterations of the Digital Stories on Textile project were used to create and make explicit the sustainability qualities. Now it becomes clear how the sustainability qualities in combination with the craft qualities (Chapter 4) guided the design process.

5.4.1 APPLYING THE FIRST VERSION OF SUSTAINABILITY QUALITIES

The identified insights into the sustainability qualities in smart textile services redefined my previous understating and therefore influenced the new version of Digital Stories on Textile project – Textales Dream Bear and Sunny Sunday editions. These projects built on the two previous projects: QR-coded Embroidery and Bedtime Stories. While creating the concepts and requirements for the next iterations, the following aspects from the sustainability point of view were considered.

Both the digital and the textile components need to be considered to minimise the environmental sustainability burden resulting from the use of Textales. The design of the Textales application has to support iOS and Android devices. The applications should function offline most of the time. The textile material should be of high quality and as pure as possible. The service envisioned for the Textales design has to support the longevity of the textile. Therefore, the items should carry clear caretaking instructions. The labeling should also make the value of the material explicit. The application should be able to develop in time to work with newer tablet devices. The application should change in time to adapt to the changing needs of the users. The users should be able to create new stories, modify and share the existing ones. The software should provide the users the freedom to create content as freely as possible. The action of creating and sharing stories should enrich interaction within families.

The identified sustainability qualities acted as guidelines for designing the next version of the Bedtime Stories - Textales. The collaborative project Textales Dream Bear edition started out as a commercial-like example with the industry partners. It turned out to be impossible to apply the sustainability qualities that build on open-source and do-it-yourself principles to the custom-made, almost commercial, version of Textales at that time. That is why I started to develop an alternative version, Textales Sunny Sunday edition, with a group of friends, to apply the qualities based on openness and personalisation. The latter, not having any commercial ambition, and built on free third-party software, allows more experimentation with community-based and open-source ideas.

5.5 SUSTAINABILITY QUALITIES IN TEXTALES

My redefined understanding was presented again to the experts in the sustainability fields. In the review round, the sustainability experts commented on the sustainability qualities and my redefined understanding of them. The sustainability qualities in Tex-

tales Dream Bear and Textales Sunny Sunday editions were presented to the experts to validate and enrich my understanding of the sustainability qualities. Through that, the second version of the sustainability qualities was achieved.

METHODS FOR COLLECTING AND HANDLING DATA 5.5.1

The environmental sustainability expert, Dr. Andreas R. Köhler, and the eco-social sustainability expert, Professor Alastair Fuad-Luke, who already knew the concept of the project from the interviews, agreed to reflect on the first version of sustainability qualities in the context of Textales Dream Bear and Sunny Sunday editions. Kuisma was not able to participate in the additional study. To evaluate economic sustainability, I introduced the project to a new expert – Dr. Nancy Bocken (Bocken, 2015). Bocken is an Associate Professor at TU Delft, Senior Research Associate at the University of Cambridge, and a Fellow at the Cambridge Institute for Sustainability Leadership (CISL). Her research interests include sustainable business models, closed loop economy, eco-innovation and eco-ideation, systems change and closing the idea-action gap in sustainability (Bocken, 2013; Bocken et al., 2015b).

The sustainability experts were approached by e-mail to explain the reasoning behind the questions they would receive. The information about both of the Textales editions was shared in equal level of detail. The sustainability qualities were described through how they had been applied to Textales Dream Bear and Sunny Sunday editions, and the experts were asked to fill in a form where they could indicate their thoughts and impressions about each sustainability quality for both projects. They were asked to comment on each of the qualities, as well as how they saw them present in the project. The experts could approach me by e-mail, Skype or phone for any questions and clarifications at any time. Since the sustainability expert giving feedback on economic sustainability was new to the project, I met her personally at TU Delft. I gave her a brief background introduction to the project and the same information as that given to the environmental and societal sustainability experts.

The next section presents the insights gained about each sustainability quality in Textales Dream Bear and Sunny Sunday editions from the sustainability expert reviews. Each quality will be discussed in detail through the thoughts of the experts and my reflection on those.

IN TEXTALES DREAM BEAR EDITION

IN TEXTALES SUNNY SUNDAY EDITION

Sustainability qualities	SQ redefined understanding of the designer-researcher	Dr Andreas Köhler	Prof Alastair Fuad-Luke	Dr Nancy Bocken	Dr Andreas Köhler	Prof Alastair Fuad-Luke	Dr Nancy Bocken
SQ1 Minimizing Consumption	The application has to support all major OS systems running on the main popular smart devices, to avoid buying new devices. The textile open/generic to new stories?	I see a risk of increasing consumption of IT resources (more hardware is needed) and energy (due to longer operation time of IT gadgets). Depends on user behavior and is hard to anticipate. App should be compatible to run on older devices (e.g., parents' 5 years old devices passed on to the kids would allow for cascade use).	The key limiting factor (KLF) would appear to be the viability of the commercial value proposition for the digital components and the making of the analogue components to read by scanning. If either of these are challenged by market trends and economics then the 'storytelling' fails. Backwards/forwards compatibility of the OS/Apps/Platform is an issue too because obsolescence is a feature of the digital world!	It might reduce the number of books printed, if multiple stories can be added to the same cloth.	Question is, do the users really want to buy an extra textile playing cloth? It appears the textile may become a rather superficial element in the VR context.	KLF is whether the community of Junaio developers and content providers and the provider of the development platform see individual or collective gain in the future. Backwards/forwards compatibility of the OS/Apps/Platform is an issue too because obsolescence is a feature of the digital world!	If I make it myself, I might like it better and look after it more?
SQ2 Controlling Energy and Chemical Use	The application needs to keep working locally on the user's device to minimize online time for less energy use. The materials for the textile need to be chosen carefully considering their environmental impact.	Yes, the app may help saving energy if it does not require extensive use of Internet resources (uploads/downloads). I don't see any direct impact on chemical impacts of textiles (detergents). But the app-content (story) may feature educational elements to wake up the interest in ecological aspects of the product.	I see little or no difference between these two systems but BOTH depend upon the 'cyber-sustainability' of the internet and its energy and political futures.	There is more control, but only over the production phase and not over the extended use unless the bedsheets are leased.	It would be beneficial for the environment if the app is really able to make people using it instead of committing other, more energy and resource intensive activities. Doubtful whether this is realistic to assume but certainly worth a try.	I see little or no difference between these two systems but BOTH depend upon the 'cyber-sustainability' of the internet and its energy and political futures.	Less control over materials used, unless you give the people a DIY kit (as Arduino for example). It could function as a Lego platform.
SQ3 Developing Constantly	The application needs to be compatible with newer devices constantly coming out.	Important point! Think of community based / open innovation concepts (open source, creative commons) as means to keep the product development alive. Moreover, the content my feature a scalable educational concept that gradually adopts to the growing knowledge of the kids (and their changing interest in different subjects).	KLF is the 'Value Proposition'(VP).	More control.	Agreed.	KLF is the activity of the community of content providers and the willingness of the developer of apps and platform provider. I notice that the Junaio community platform is only guaranteed until 15.12.2015!	Android also supports upgrades, community of developers.
SQ4 Caring for Longevity	The textile has to live up to its potential (live long), which means it needs to be taken proper care of.	I guess the longevity of the bed dress may be higher than the longevity of the virtual reality (VR) application. This depends on the quality of the textile material (wear & tear rate) compared with the turn over of IT gadgets (assume 3 years for hardware).	Maybe a leasing/renting service makes more sense as additional 'scannable textile elements' can be added through the life cycle and repairs made. 'Upgrades' can also happen as stages in the service life.	Leasing/ service contracts or deposit systems.	Think of a second use purpose for the textile.	Maybe a leasing/renting service makes more sense as additional 'scannable textile elements' can be added through the life cycle and repairs made. 'Upgrades' can also happen as stages in the service life.	Communities that teach repair, such as Fixit.
SQ5 Supporting Meaning Creation	The user must be able to create new stories ; the user must be able to develop and share their stories.	I think this is an essential element of the VR concept that helps to develop the children's imagination, creativity and fantasy. In this respect, it would be good to allow users to preserve the stories into future like a digital diary (alongside with the bedsheet) (think of 25 years + for the children's later own kids).	Commercial constraints of the VP; Motivation of the parents?; Ease of use of technology for users is critical.	Parents are always creative - they also use the same book over and over.	Yes, adults too may want to create and preserve digital VR contents like a diary.	Commercial constraints on the App developers and platform providers? Motivation of the community of content providers? Ease of use of technology for content uploaders and downloaders.	Easiest to create totally different stories.
SQ6 Updating the Product	The application needs to develop over time to adapt the changing needs of the user.	The VR content may trigger demand for new bed dresses with different printed patterns. My guess is that children, as they grow, get more easily bored by the Dream Bear story and ask soon for other stories. This may lead to accelerated obsolescence of textiles. To avoid this kind of VR-triggered throw-away effect, it would be good to offer more VR stories for the same printed pattern, e.g., other fairy tales that play in a forest.	Commercially driven model.	Leasing allows the business to update everything (textile and application).		Provider driven model. Platform driven model.	Facebook-like community idea to keep in touch, physical meeting places. Used for a business/company? Working together remotely? Teaching? Make teaching more interactive?
SQ7 Empowering Positive Emotions	The application has to be easy to use, the technology must allow the freedom to create the stories freely, with no major limits.	Yes, a possibility for the user (kids) to add their own elements to the original story (introduce more characters, add on story elements) would increase the emotional attachment to the bed dress - hence increase the desire to use it for longer time (like a diary).	Motivation of parents, children to use their creative energy in the analogue/digital (hybrid) environment of duvey + iPad? Stories can be very personal and <i>not</i> for sharing with others.	It would be nice if I had a scanner or a camera I could immediately become part of the experience (as an avatar).		There are issues of content generation, the quality of content, privacy issues (personal stories) and the usual demands of security that might make people cautious of sharing content.	Standardise the integration of people's own characters.
SQ8 Building Relationships	The character of the story creation and sharing has to support interaction within the families.	Story sharing among friends is a good point to achieve the same as above. Beware of particular privacy and digital security needs of children (using an internet controlled camera in children's bedroom may be an easy target for criminal abuse of technology).	There is insufficient empirical evidence in the project to comment but the experience must reward parents, children and the commercial provider. Does this hybrid digital/ analogue environment build BETTER relationships than reading bedtime books or sharing bedtime videos?	Ability to add family members + dog to the story. Maybe it would trigger people to not buy a dog, if they can care for the virtual one.	May be more difficult for adults than for children.	There is insufficient empirical evidence in the project to comment but the experience must reward parents, children, the content providers and the (commercial?) platform provider.	Ability to add family members and a dog to the story. Maybe it would trigger people to not buy a dog, if they can care for the virtual one.

Table 4 The redefined understanding of the designer-researcher of the sustainability qualities in smart textile services context and the comments from the sustainability experts Köhler, Fuad-Luke and Bocken.

5.5.2 RESULTS FROM THE SUSTAINABILITY QUALITIES REVIEW

Table 4 presents my redefined understanding of the sustainability qualities in the smart textile services context and the insights gathered from meetings with the sustainability experts Köhler, Fuad-Luke and Bocken. For example, my redefined understanding of the sustainability quality Minimising Consumption (row 2, column 1), which was formed based on the Bedtime Stories project, is that the application has to support all major OS systems running on the most popular smart devices, to avoid the necessity of buying new devices. Also, the textile should be generic enough to accommodate different stories on one cloth (row 2, column 2). Köhler commented on the same quality in Textales Dream Bear edition saying, “I see a risk of increasing consumption of IT resources (more hardware is needed) and energy (due to longer operation time of IT gadgets). Depends on user behavior and is hard to anticipate. App should be compatible to run on older devices (e.g., parents’ 5 years old devices passed on to the kids would allow for cascade use)” (row 2, column 3). Fuad-Luke pointed out the limitation of the commercial value proposition for the digital components and manufacturing the analogue components to scan the Textales Dream Bear version. He added, “If either of these are challenged by market trends and economics then the ‘storytelling’ fails. Backwards/forwards compatibility of the OS/Apps/Platform is an issue too because obsolescence is a feature of the digital world!” (row 2, column 4). About the same, Bocken wondered, “It might reduce the number of books printed, if multiple stories can be added to the same cloth” (row 2, column 5).

Regarding the Minimising Consumption quality in the context of Textales Sunny Sunday edition, Köhler wondered whether people would like to buy an extra playing cloth. He pointed out “It appears the textile may become a rather superficial element in the VR context” (row 2, column 6). Fuad-Luke pointed out the limiting factor for Sunny Sunday edition being the community of Junaio developers and content providers and whether the provider of the development platform sees possible individual or collective gain for the future. He mentioned that “Backwards/forwards compatibility of the OS/Apps/Platform is an issue too because obsolescence is a feature of the digital world!” (row 2, column 7). Bocken posed a question that “If I make it myself, I might like it better and look after it more?” (row 2, column 8)

Next, each quality will be explained, following the comments of the three sustainability experts.

5.5.3 SECOND VERSION OF THE SUSTAINABILITY QUALITIES EXPLAINED THROUGH THE TEXTALES DREAM BEAR AND SUNNY SUNDAY EDITIONS

All the sustainability qualities are explained individually, first introducing the quality through how it was found, based on the Bedtime Stories Little Red Riding Hood project, then showing my redefined understanding of the sustainability quality in the Textales Dream Bear and Sunny Sunday editions. After that, the comments from environmental, societal and economic sustainability experts are presented with my reflection on each of them. At the end of each quality description there is a short definition that generalises the quality.

The Textales Dream Bear edition is an example of a commercially finished and custom-made product, and Textales Sunny Sunday edition is an example of a community built product, based on freely available end-user software. In principle, both projects function similarly. They differ

primarily in the software that they use, and what it allows the users to do. Each project is made to explicitly reflect on the opportunities and limitations that the approach triggers.

SQ1: MINIMISING CONSUMPTION

Since the iPad turned out to have the most impact on environmental sustainability in Bedtime Stories, avoiding new device purchases should be the priority for the re-design. Therefore, the final application has to be compatible with a range of devices to accommodate the longevity of the textile and avoid the temptation of buying more and newer devices. Even though the textile duvet cover and pillow environmental impact was considered to be negligible in comparison with the smart device, it would be beneficial if the textiles would be able to accommodate several stories on the same canvas and be interesting for a longer time.

Dream Bear was developed to work on iOS 8.0 and later and Android 4.0 and higher tablet and smartphone devices. Even though the application is expected to function on some future versions of those operation systems, there is neither extra maintenance nor development planned, and the software cannot be expected to be always compatible with new systems.

The forest setting of the Dream Bear textile (Figure 73) is quite particular to the story, allowing the family to also experience the story without the smart device. Other forest, bear and camping related stories could be placed on the same canvas. Also, the story can have several sequences of action and different endings since the story creation is opened up for the parent. They can choose to display it in sequence, random, or open mode.



Figure 73 Textales Dream Bear duvet cover carries many detailed forest elements.

Sunny Sunday works using the Junaio (2015) application. Junaio is compatible with iOS 6.0 and later and Android 2.3.3 and higher tablet and smartphone devices. Junaio is supported by Metaio, a leader in Augmented Reality technology which is continually developing its software products. At the moment of writing, a new Beta version, Junaio Mirage, is available for smart glasses (Epson, Vuzix, Google). Therefore, the software can be expected to develop steadily, providing new features for the users, and also motivating them to create new and other types of content.

The Sunny Sunday textile exposes several landmarks (Figure 74) across the Netherlands. Some of them are generic - an airplane represents the excitement of traveling, volleyball net represents sports activities, a windmill represents the Netherlands, and the train station is characteristic of Rotterdam. Each group of people could have their story about specific locations. The people who were part of the Sunny Sunday group drew the objects that played a role in their history.



Figure 74 Textales Sunny Sunday canvas consists of several landmarks across the Netherlands.

Expert view on environmental sustainability

In the Textales Dream Bear edition, the experts saw a risk of consuming more IT resources and energy when operating the electronic gadgets for a longer time. They said it depends largely on user behaviour and is, therefore difficult to predict. Köhler expressed the importance of making the application compatible to run on older devices, because of parents passing older devices on to their children, and how this would allow the devices to be used longer.

In the context of Textales Sunny Sunday edition, Köhler posed a question, whether the users want to buy an extra playing cloth. He felt it to be possible that the textile could become a rather superficial element in the technical context.

My reflection on environmental sustainability

It is clear that if the project wishes to promote slower consumption, any new software should work on older operating systems and hardware. This is achievable, to some extent. I found several opportunities in what Köhler said about using older devices for such purposes, and in that way also extending their life spans. Newer, more powerful devices with new possibilities

and features will always keep coming out. With Textales, the project team could explore both, making the application compatible with older as well as newer devices. There are opportunities to explore both. And what is most important, users need to be able to use their existing devices. Perhaps consciously developing applications for older devices would keep devices in use for a longer period of time. However, they also face an expected expiration date, and the transition to a newer system should be as effortless as possible. Köhler questions whether people want to buy new textiles to be able to access the stories. That question triggers an interesting aspect about whether the textile or the software is seen as the primary object for the project. The central element of the project is envisioned to be the textile. This project enhances the traditional fabric canvas with an Augmented Reality layer with the hope that this inspires people to use it longer, personalise it and get the most value from using it. The project team tried to embed a meaning, message and magic in the textile via technology. It is a very relevant question and concern to take into account, to make sure that the application would not force the user to obtain a new textile that is not needed.



Figure 75 Textales Dream Bear edition characters can be seen through various devices and OS systems.

Expert view on societal sustainability

Fuad-Luke found the key limiting factor to be the viability of the commercial value proposition for the digital components and the manufacture of the analogue components to be read by scanning. If market trends and economics challenge either of these then the storytelling would fail. He also pointed out the issue of backwards and forward compatibility of the OS/Apps/Platform as a feature of the digital world.

The key limiting factor in Sunny Sunday for Fuad-Luke was whether the community of Junaio developers, content providers and the platform provider see an individual or mutual gain in the future. Backwards/forwards compatibility of the OS/Apps/Platform is an issue as well because obsolescence is a feature of the digital world.

My reflection on societal sustainability

Technology and the development of Augmented Reality devices have a significant risk for the concept. In the scope of one app and project, it could be that the tablet and smartphone devices get neglected before a textile duvet cover or a picnic sheet wears out. In the larger picture, thinking about the concept of textiles telling a story, the devices could always change. As long as the same textiles are linked to new stories (as well as old stories) they can keep carrying a meaning for the user. Just as any other medium, they would change in time.

Expert view on economic sustainability

Bocken saw the possibility of reducing the number of printed books in Dream Bear as it could accommodate several different stories on one duvet cover. She saw the benefit in enabling people to experience different stories in one medium.

In the case of Sunny Sunday Bocken wondered, if people had made the item themselves, whether they might like it better and look after it more carefully.

My reflection on economic sustainability

Dream Bear is a hybrid product combining the functions of a duvet cover and a book. It can be handled like a regular duvet cover. However, it cannot be handled like a printed book, as we know it. It changes the way stories are told and experienced. Instead of printed linear stories, children can experience more dynamic and playful, even game-like scenarios. Digital stories have a different environmental footprint than printed books, they also ask for entirely different business models. Therefore, what Bocken poses as a possibility for printing fewer books could actually trigger a whole different series of thoughts about how to commercialise such duvet-book hybrid product-services.

Another point that Bocken brings up about people taking better care of items they have made themselves links to the emotional attachment people have with the product (either textile or digital side). Additionally, they may learn a new skill while making and adapting the canvas and content of Sunny Sunday.

Definition ***Minimising Consumption is about slowing down the consumption of both textile and technology. The quality is in experiencing maximal value using the minimal material resources.***

SQ2: CONTROLLING ENERGY AND CHEMICAL USE

Offline applications consume less energy than online streaming. The application should work locally offline rather than online. The impact of the use of 100% cotton material for the woven textile is negligible from the disposal point of view. However, cotton environmental impact involves extensive use of scarce fresh water for irrigation and power consumption for pumping water. The extensive use of fertilisers and pesticides leads to chemical pollution alongside the dyeing and bleaching of the spun fibers. Typical aspects of the production chain, such as weaving, sewing, ironing, should not be omitted from the impact picture as well. The primary goal of Textales is to minimise the textile consumption by revealing digital stories on the textile canvas. Therefore, high quality is a priority over the lower immediate impact of the materials. The user is to be made aware of the material usage and environment-friendly care methods.

Dream Bear is a local application that needs an Internet connection only to be downloaded. But after it is installed on the smart device, it does not require an Internet connection for functioning. If new stories or updates became available, an Internet connection would be necessary to retrieve them. Sunny Sunday needs an Internet connection to load the Junaio channel for the specific story. Once the channel is loaded, it can work offline. The free version of the Metaio software allowed two content items in one channel when the current version was developed. That means the user could use the application to recognise a maximum of two markers on the cloth, after activating the channel by scanning a QR-code. Therefore, the objects or information seen within one channel are limited to two markers for the free license version.

Pure cotton (Figure 76) is used to weave both Textales Dream Bear and Sunny Sunday editions to keep natural materials in children's beds or otherwise close to human touch. The textile project partner uses ethical methods and the least possible toxic treatments on the product. Weaving, cutting, sewing, and finishing of the products are done in Europe following EU standards and guidelines for environmental sustainability. The Dream Bear duvet cover is made from four running meters of fabric and Sunny Sunday picnic cover 2.80 running meters. Both use the full width (1.40 m) of the woven fabric to avoid any material loss in cutting process.



Figure 76 Textales Dream Bear is woven from 100% cotton material yarns.

Expert view on environmental sustainability

Köhler confirmed that the Textales Dream Bear app may help to save energy if it does not require extensive use of Internet resources (uploads/downloads). He did not see any chemical impact of the textiles. He pointed out that the application content (story) could feature educational elements to encourage the interest in environmental aspects of the product.

Köhler found it beneficial for the environment if people would use the Textales Sunny Sunday app, instead of committing to other, more energy and resource intensive activities. He expressed doubt whether this would be realistic to assume but certainly found it worth a thought.

My reflection on environmental sustainability

The added benefit of the application working locally on the device was confirmed by the expert review. Also, Köhler pointed out that there are opportunities to direct the content of the stories towards sustainability and educational aspects. The sustainability experts saw the primary benefit of such a combination in the quality of the use time of the product. If Textales offers a fulfilling experience that enhances people's lives beyond the storytelling time and contributes to their lives more positively than a textile object and tablet device separately, then the material influences could be neglected from the sustainability impact.

Expert view on societal sustainability

Fuad-Luke mentioned seeing little or no difference between Dream Bear and Sunny Sunday concepts but pointed out how both depend on the "cyber-sustainability" of the Internet and its energy and political futures.

My reflection on societal sustainability

Being an application for mobile technology, the concept relies on the future of the Internet and technology in general. The same idea and same way of telling a story also cannot last forever. It is only natural to expect it to change in time. Also books are rewritten from time to time to better

fit current times. As recommended by the experts, the energy and political future of the development of the Internet has to be kept in mind.

Expert view on economic sustainability

Bocken pointed out that in Dream Bear there is more control over the energy and chemicals used in the production phase. She saw a leasing business model for the duvets as an option to gain control also over the energy and chemicals used during the extended use and care of the duvets.

For Sunny Sunday, Bocken saw less control over the materials used. She suggested that giving a premade kit for people would give back some of this control. She saw it functioning as a Lego (LEGO Group, 2015) platform.

My reflection on economic sustainability

The balance between control and freedom is a complicated matter. I agree with Bocken that in Dream Bear the makers can control many aspects of the production, until it leaves their hands. In the way the textile industry works today, the makers cannot get access to all the information involved in the process though. Therefore it is essential to note that the makers should take responsibility to make sure every aspect of the production from growing crops to the final product packaging would be ethical and transparent.

It is a fascinating idea to make Sunny Sunday into a DIY kit that has all the needed elements included for people to make their stories. It could also attract people without prior textile or digital experiences to play with the materials and create value through new experimentation.

Definition ***Controlling Energy and Chemical Use is about making choices for the product to use minimal energy and chemical input within its production and use phase.***

SQ3: DEVELOPING CONSTANTLY

The Textales software has to develop along with the changing needs of the user. It should have ongoing development within the community or a service supporting it. It could be beneficial to review existing stories and to create new ones. The application needs to work on the newest devices; that means that constant development from the software side is a definite requirement.

Dream Bear can be updated and developed into a new story by the original authors. The story can receive updates if the development team continues working on the project. This would be the aim should there be commercial interest.

Sunny Sunday can be updated by anyone who wishes to do so. It can be done using any freely available image recognition Augmented Reality software. The idea of the project is to promote active making and creativity instead of passive consumption, therefore, even if the tools change and Augmented Reality becomes obsolete, people might be able to enrich the cloth with something more innovative.

Expert view on environmental sustainability

Köhler found this to be an important aspect. He suggested looking into community-based and open innovation concepts as a means to keep the product's development alive. Moreover, Köhler pointed out the opportunity to link the content to a scalable educational concept, which could gradually adapt to the growing knowledge of the children. Köhler agreed with the proposed open source DIY model of Sunny Sunday.

My reflection on environmental sustainability

As children (and people in general) are often quick to change their interests in various topics, the stories and the system needs to adapt to these changing interests. In a future scenario, the story could create more depth in a particular direction and develop further based on the changing interests of the family. For example, the Textales application could observe that the particular family likes to investigate.

Expert view on societal sustainability

Fuad-Luke found the primary limiting factor in Dream Bear to be the value proposition. The user would expect a particular value from using the product. Fuad-Luke found the key limiting factor in Sunny Sunday to be the activity of the community of content providers and the willingness of the developers of the software application and platform providers to keep offering their services open source and free of charge. He noticed that the Junaio community platform was only guaranteed until the end of 2015.

My reflection on societal sustainability

It needs to be very clear to the user that they can only create the value from the way they choose to use the application. Textales stories, however, should indeed follow a particular value system. The premade stories could, for instance, be fairy tales with modern twists.

The Junaio platform may not last longer than 2015, because Metaio, the platform provider, was acquired by Apple (Miller & Constine, 2015). However, the concept is not limited to a specific software provider and the framework can be applied to different platforms. For example existing projects can migrate to CraftAR (Catchroom, 2015), where the first thousand visual scans are free of charge, or the open source solution Mixare (www.mixare.org) or commercial solutions such as Aurasma (www.aurasma.com) and Layar (www.layar.com), among others.

Expert view on economic sustainability

About the constant development, Bocken found Dream Bear to have more control in the use phase. The project team can send updates and renew the stories however they please. They can also create new ideas and ways of using Textales. Sunny Sunday's development, according to Bocken, depends on the community of developers.

My reflection on economic sustainability

The fact that Dream Bear can only be edited and developed centrally by the team of makers can be seen as a benefit or challenge. On the one hand, professional and organised developments can be arranged to assume there is a market need for it. On the other hand, if the providers are not able to deliver new stories or keep the application going, then it would become impossible to use it. It does not trigger much creativity to find other solutions for keeping the digital stories on the duvet.

It is less possible to control or predict what kind of directions open source programs and teams would go in the case of Sunny Sunday. That also has its advantages, since open communities can come up with the most extraordinary ideas and solutions. Allowing the project to grow in that direction could mean different, unexpected directions or it could also mean that nobody would be interested in picking it up.

Developing Constantly is about moving from a product that can be delivered into a service system that allows the software and support for users to be up to date.

Definition

SQ4: CARING FOR LONGEVITY

The textile working with the application needs to support the long-lasting product concept. The material can be kept functional and aesthetically pleasing through proper maintenance. Introducing a new type of textile item carries the possibility of also introducing new care principles to users. Therefore, the smart textile item needs to be supported by carefully selected care instructions. Other alternatives for strengthening the textile longevity may include setting up leasing or renting systems and making sure the items get maintained centrally by a professional care service provider. Product-specific repair and re-use inspiration could support the creative alternatives for the end of life of the duvet cover and pillow covers that could easily turn into kitchen towels or other smaller items used in the household. Support for such remaking could potentially lower the threshold for the owner to get started with such practises.

Both Dream Bear and Sunny Sunday use a 100% cotton woven duvet cover and a pillow cover or a picnic sheet respectively. The consistency of materials makes the caretaking clear for the user. It helps to grow their knowledge about materials. Textales has a stitched-in care label saying “100% cotton and creativity” and an accompanying message to the user elaborating more about the materials and the recommended use (Figure 61).

Expert view on environmental sustainability

Köhler pointed out that the longevity of the Dream Bear duvet cover is probably greater than the Augmented Reality application. He stated this based on the quality of the textile material (wear and tear rate) compared to the turnover of IT gadgets, which is assumed to be three years for hardware. In the context of Textales Sunny Sunday, Köhler suggested thinking of a second use purpose for the textile.

My reflection on environmental sustainability

The Dream Bear duvet cover is also perfectly functional without the app, and maybe the stories live on in the forest even when the application does not work anymore. However, it is important to make sure the duvet cover is not disregarded due to newer devices becoming available. The Sunny Sunday picnic cloth can be used or made into anything. It is a valuable suggestion to explicitly point these options out for the users.

Expert view on societal sustainability

Fuad-Luke recommended a leasing service for Textales Dream Bear and Sunny Sunday editions. According to him, the additional “scannable textile elements” can be added that way through the life cycle of the textile item. Renting services also support the idea of mending and repairing the duvet cover when needed. Fuad-Luke mentioned that “Upgrades” could also happen during the service life of the items.

My reflection on societal sustainability

Keeping the ownership of the textile object with the producer or service provider would ensure that users would allow for the professional care of the products. Moreover, the items could circulate more because they would not be stored in people’s closets. They would be motivated to bring back the duvet that they do not use any longer, and exchange it for another story canvas.

Expert view on economic sustainability

Bocken recommended lease and service contracts or deposit systems for achieving better care throughout the natural life of Dream Bear. With rental and service contracts, the ownership of the product would stay with the service provider, therefore, the responsibility to care for it as well. With a deposit contract, the user would have ownership but would be motivated to bring

the textile back to the service provider when they do not want to use it anymore. Receiving economic benefit or a new item in exchange would motivate the user to keep the cloth in a healthy state. The service provider could either send the used items back into the use cycle, if they are still usable, or dispose of in an environment-friendly way. In Sunny Sunday, Bocken saw the opportunity for communities to emerge that teach repair, such as iFixit (2015).

My reflection on economic sustainability

It would help to have incentives for people to care for the textile duvet or picnic cover, such as a deposit they would receive for bringing it back to the service provider, once they have finished with it. There are models for leasing apparel (Engeström & Jokinen, 2011; Mud Jeans, 2014) but at least at first it could be more acceptable for users (Armstrong et al., 2014) to own their duvet cover rather than to lease it.

Repair and DIY communities could be the early adapters of the Sunny Sunday concept, already having skills and desire to make and fix things. However, it would also be interesting to introduce the curiosity to create and build to people outside of those communities.

Caring for Longevity is about providing durable materials (both textile and software) and concepts that can last.

Definition

SQ5: SUPPORTING MEANING CREATION

The application has to support the creation of meaningful stories by the user. It is important to provide inspiration and tools to the local storytellers and to the end user to create and share their stories through the Textales concept.

With Dream Bear, the opportunity to create and tell a local story is given to an Eindhoven-based (the home town of the project) writer-illustrator. The duvet cover is carrying a forest scenario with adventures of a bear on it. In Augmented Reality the characters he meets during his journey appear. It is up to the families themselves to weave their personal stories into the pre-made characters associated with the bear. They are encouraged not to use the default mode of a linear story, and come up with random sequence and adventures reflecting their experiences instead.

A group of friends tell a story about their experiences and memories in Eindhoven in a given period through Sunny Sunday. They choose relevant symbols (a cake, an airplane, etc.) to use as markers on the textile and connect chosen memories or people to the symbols digitally. The textile design represents meaningful places for them as a group or personally, and 3D characters represent some of their friends (Figure 77) and joint activities. The content of the digital layer of this edition is open for anybody to change or update.

Expert view on environmental sustainability

Köhler found the possibility of families creating their stories essential for the development of children’s imagination, creativity and fantasy. He recommended allowing users to save their stories in a digital diary, perhaps even for 25 years or more, so that they could be later told to a new generation of children. Köhler noted the same about Sunny Sunday, to allow the adults to create and preserve their digital Augmented Reality content in a diary format.

My reflection on environmental sustainability

The idea of storing special versions of the Dream Bear story is very interesting. It would also work well with parents being able to add extra characters into the storyline (family dog, cat, turtle, friend, etc.) and enrich the experience through personalisation. As a first step, the user

should be able to save the sequence in which they like the characters to appear in the story. As a further development, it could be found out which format (voice recording, screen capture or something else) would be the easiest and most valuable for the user for saving their stories.

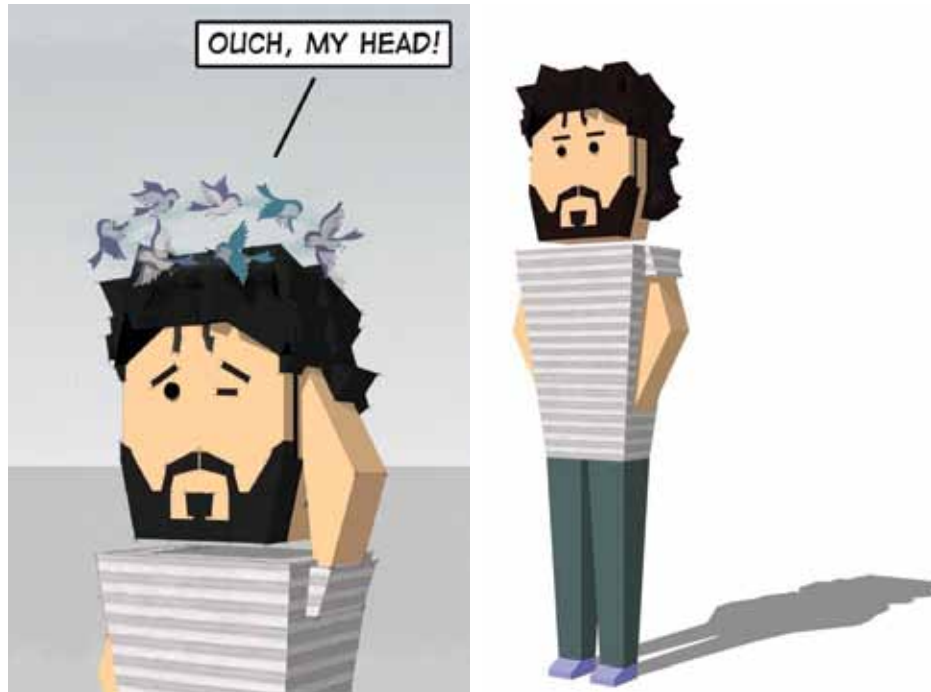


Figure 77 Guille, as the main character of Sunny Sunday, 3D model by Jack.

Expert view on societal sustainability

Fuad-Luke asked about the motivation of the parents in creating stories with Textales Dream Bear. He also stated that the ease of use of technology for users is critical. He pointed out the restrictions in creating new stories within both projects being commercial. About Sunny Sunday, Fuad-Luke asked about the motivation of the community of content providers. He stated again the importance of the ease of use of technology for content uploads and downloads.

My reflection on societal sustainability

The Textales Dream Bear application is user-friendly. It is made by focusing on simplicity and clarity. The user simply opens the application, selects whether she would like to use the application in the narratives on, off or random and starts scanning the duvet cover. However, the Textales Sunny Sunday runs at the moment on Metaio/Junaio platform and, therefore, requires some extra steps. Before the user can see the Augmented Reality layer, she has to scan a QR code to load a certain channel in the application.

Expert view on economic sustainability

In the context of the Dream Bear story, Bocken mentioned that parents are often creative. They manage to tell a different story even with the same characters. They use the same books over and over. In fact, sometimes children want repeated stories instead of new ones. Bocken found it easier to create new and different stories in Sunny Sunday project.

My reflection on economic sustainability

To support the needs of different parents, the Dream Bear story has to come in different versions, for example in a version where the parents do not need to think at all, and can just repeat the story that is asked by the child. Maybe the application should allow the parents to record or remember the sequences and storylines. For more playful moments, the application should also support complete freedom to create new type of stories, perhaps matching the topics and questions relevant to the family in that day.

Sunny Sunday allows creative freedom in both textile and digital canvas – perhaps too free for some people? Sometimes limits can help and guide the creative process.

Supporting Meaning Creation is about providing an intuitive and simple platform for the users to share and communicate their values.

Definition

SQ6: UPDATING THE PRODUCT

Life and everything around people changes at an incredible pace. Products can keep the feeling of familiarity in people's surrounding or go along with the changing times by constantly being renewed; or they could be somewhere in between - physically static and familiar and digitally up-to-date and capable of change. The use of the digital-physical connection in Textales can be essential for keeping the product attractive to people for a longer time, through new stories and the possibility to change and add to the existing stories.

Dream Bear is a project-based developed prototype. The authors themselves can update it, but not any external party. For the authors to work on it, commercial support or another type of funding is needed. Since the Dream Bear itself is not intended to be a commercial product, the updating and changing aspects of it are poorly represented in the concept.

Sunny Sunday serves as a platform with generic locations that each family or group uses to create its own meaning. By the use of end-user tools for image recognition and Augmented Reality, the picnic sheet serves as an open canvas for anyone to present their story.

Expert view on environmental sustainability

Köhler confirmed the importance of renewing the stories on the same duvet cover. His concern was that otherwise, the children would get bored with the same story and ask for new duvets.

My reflection on environmental sustainability

Textales Dream Bear duvet cover is quite specific for the story. Even if the children can experience the narrative in different sequences, depending on the parents' creativity, there is a limitation to the number of variations. A more generic canvas that would accommodate several forest fairy tales could be more sustainable.

Expert view on societal sustainability

Fuad-Luke confirmed the Dream Bear as a commercially driven model and Sunny Sunday a provider/platform driven model.

My reflection on societal sustainability

The updates for the Dream Bear story and narrative could come from the team of Textales. To gain means to develop the Textales application further, the team would need to commercialise the concept. Sunny Sunday, however, relies heavily on the platform providers. On the other hand, people are free to create personal content, as well as public content constantly.

Expert view on economic sustainability

Bocken pointed out that in the Dream Bear case, a leasing model would allow the business to update both the textile and the application parts. In Sunny Sunday, Bocken suggested looking into community-based ideas for keeping in touch. She talked about groups that gather in virtual spaces based on mutual interesting topics, but also in physical meeting places. She asked questions such as “Could it be used for businesses? Could it be used for working together remotely? Teaching? Could it make teaching more interactive?”

My reflection on economic sustainability

It could be beneficial to keep the ownership of the textile with a company leasing the product. This approach might stop people from personalising it, though. Maybe it needs to be flexible, so that people can choose which approach would fit them best, to buy and customise or to lease the Dream Bear story.

Groups and communities, where people have physical contact as well as virtual means to communicate, could benefit from the Sunny Sunday concept. It could be a group of friends, families, students, colleagues, or other collectives of people. It could be helpful in different situations where a physical representation of information or people would be meaningful. I see quite some opportunities for using the technology for teaching. For example, to explain physics or math to younger children through experimenting with a textile, and, therefore, seeing and experiencing themselves what the concepts otherwise seen in numbers on papers, would mean.

Definition **Updating the Product is about the way users/people can update the textile product through adding and adapting digital content.**

SQ7: EMPOWERING POSITIVE EMOTIONS

The application needs to allow the users to focus on the content and enjoy the use of Textales. It needs to be easy to use. Any extra effort for learning and handling of the application needs to be minimised. A simple, intuitive, and clear interface helps to share the positive emotions without too much of a distraction from the technology (Figure 78). The stories need to be dominant with respect to the technology. Technology should not pose significant limits to the story creation.



Figure 78 The positive emotional moment between siblings is supported by the simple to use application interface of Textales Dream Bear edition.

Dream Bear has a simple user interface with only a few necessary buttons (Figure 79). The 3D content appears on the screen either in defined order, randomly, or wholly open to maximise the way that Textales can be used. The text box showing the story lines can be visible or hidden. Sunny Sunday utilises the interface provided by Junaio and the application is limited by the few features of Metaio.



Figure 79 Screen views of Textales Dream Bear and Sunny Sunday editions.

Expert view on environmental sustainability

Köhler agreed that the possibility of adding personal story elements to the pre-made Dream Bear and Sunny Sunday story would increase the emotional attachment to the textile and, therefore, increase the desire to use it for a longer time.

My reflection on environmental sustainability

In Textales Dream Bear, further development needs to include a way for users to add their characters to the story. In Sunny Sunday, the Metaio Creator currently used for creating content could be more intuitive. With the developing technology, we can expect more usable tools for connecting Augmented Reality and image recognition in the near future.

Expert view on societal sustainability

In Dream Bear, Fuad-Luke pointed out the importance of the motivation of parents and children to use their creative energy in the hybrid environment of duvet cover and tablet device. He mentioned the possibility of stories being very personal and not for sharing with others. In Sunny Sunday, Fuad-Luke suggested having a look at content generation issues, the quality of content, privacy issues and the security aspects that might make people cautious about sharing content.

My reflection on societal sustainability

The application does not capture any information at the moment. However, the issues pointed out would become critical if in the future it did store the information.

Expert view on economic sustainability

In the context of Dream Bear, Bocken suggested having a scanner or a camera that could make a model or take a picture of the person, so that they could become immediately part of the experience. In Sunny Sunday, Bocken he proposed standardising the integration of peoples' new characters to ease the process.

My reflection on economic sustainability

It would be a great improvement for the Dream Bear if people could add representatives of themselves into the story. Since not everybody would be keen on the idea of learning 3D modeling, some tools to make it approachable for parents with children would be beneficial. 123D Catch (AutodeskD, 2015), which is a free application that allows people to create 3D scans of any object and is available for Apple, Android, and Windows devices, could work, for example.

People can add their 3D models and other types of data in the Augmented Reality platforms according to the predefined standards. Perhaps with clear tutorials on how to scan, create and prepare the models and other types of data for the Augmented Reality platforms, customisation would become accessible for a wider audience.

Definition ***Empowering Positive Emotions is about keeping the application easy to use and allowing the users to create content freely as possible.***

SQ8: BUILDING RELATIONSHIPS

The product could be used to increase quality interaction within families. Creating an application for a smart device that is meant for children also brings the possibility of finding children alone with the tablet. Textales could rely on the idea of needing both the parent and the child for an interesting story to be told. The aim of the project is to enrich family interaction, therefore Textales should not become a game for children to play alone. Perhaps the application could be developed in a direction that also supports long-distance family connections, and in such case children could interact with the family through the tablet game.

In Dream Bear, the parent can choose whether to use the subtitles of the story while storytelling for the child, or to come up with entirely new adventures for the bear wandering in the forest (Figure 80). The parent chooses whether the ventures should appear in a predefined sequence, in a new order, or in random order. Children can explore the 3D characters through the smart device. However, they need the parent or siblings to tell them an interesting and personal story.

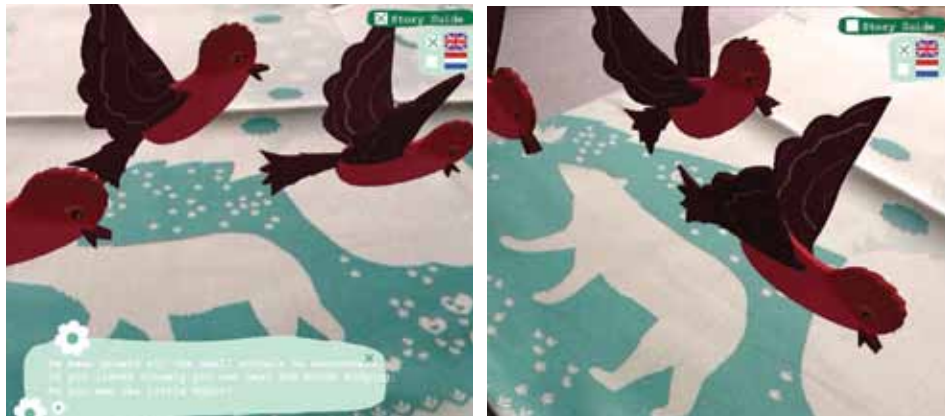


Figure 80 Textales Dream Bear edition can be viewed with or without the pre-made storyline.

Sunny Sunday connects the friends at different levels. The friends using the application do not need to be physically together, and perhaps they cannot. The digital space is uniting them for a particular period of life. Later, the cloth can be seen as a memory bank, kind of a photo album that can occasionally be accessed.

Expert view on environmental sustainability

Köhler suggested paying attention to particular privacy and digital security needs of children, especially the use of a camera in a child's bedroom.

My reflection on environmental sustainability

The mentioned recommendation is a valid suggestion, for both children and adults. All the data collected and used has to be open and controlled by the users. Sharing and other privacy properties have to be clear, simple and transparent for the users. It is hard to predict all possible use scenarios for the application; however they should be discovered and communicated openly. As seen from the secret photographing applications allowing teenagers to experiment with visual media technology (Elgersma, 2015) the use of camera in an application can be misused easily.

Expert view on societal sustainability

Fuad-Luke suggested that the experience must reward parents, children, and the commercial service provider. He asked whether the hybrid digital/analogue environment could build better relationships than reading bedtime books or sharing bedtime videos. About the Sunny Sunday project, Fuad-Luke mentioned that "There is insufficient empirical evidence in the project to comment, but the experience must reward parents, children, the content providers and the (commercial?) platform provider."

My reflection on societal sustainability

The Dream Bear is meant to provide an alternative means for the traditional book reading family moment. It changes the mode from a linear book into a network of characters, which can be aligned into a different narrative each time. The Sunny Sunday picnic cover is also meant to support the sharing and communication going on within a group already. It is a different alternative to experience the group dynamic and interaction, in person and over distance.

Expert view on economic sustainability

In Dream Bear and Sunny Sunday, Bocken envisioned the most beneficial aspect of building relationships to be the addition of people being able to add their family members and pets to the story. "Maybe it would trigger people not to buy a dog if they can care for the virtual one..." she wondered.

My reflection on economic sustainability

There could be solutions that would make it easy for people to create and upload the representations of their family members and pets into the stories. It could be as trivial as taking a photo and embedding it into a pre-made format of funny characters. Another solution would be providing users the service of creating their avatars or 3D characters. It could be either a commercially (Dream Bear) or community (Sunny Sunday) led model, where users could offer each other or the community such a service.

Building Relationships is about keeping the interaction within families or groups as the primary driver of the concept.

Definition

5.6 SUSTAINABILITY QUALITIES MEANING FOR SMART TEXTILES

The current chapter has identified and described a selection of sustainability qualities found together with environmental, societal, and economic sustainability experts, in the smart textile service examples Bedtime Stories, Vibe-ing and CHACUN(E). The sustainability qualities were applied to two re-designs of Bedtime Stories: Textales Dream Bear and Sunny Sunday editions. In Textales, Augmented Reality meets with traditional woven textile in a storytelling context. Dream Bear tackles the commercial, professional aspects of implementing sustainability qualities into a smart textile project. Sunny Sunday addresses the open source and DIY community specifics when applying the found sustainability qualities into a smart textile project.

Some of the insights gained are contradictory, and it is not possible to prefer one project over the other from the sustainability point of view. However, the challenges can be seen as opportunities for designing the service around the textile and digital application hybrid product. For example, to compare the two examples on a material level, there is much more material used in one Dream Bear duvet cover (4.00 x 1.40 m) than in one Sunny Sunday picnic cloth (2.80 x 1.40 m), however, a duvet cover can be expected to be used more often than a picnic cloth over its lifespan. A picnic cover can go from hand to hand, and get used by more people while a bed sheet is a rather personal item. A bed sheet is used indoors, where it does not get very dirty. A picnic cover is used outdoors, where it protects the everyday clothing from getting stained, but the cloth itself might need more heavy washing because of that. At the smart device application level, the custom-made application is a finished product and does not evolve in time unless commercial effort is put into it. However, a third party application, which today is freely available, could be unavailable tomorrow, as happened to Metaio/Junaio, which was acquired by Apple. Then again, it is always possible to find other solutions to migrate the information to. There are challenges and benefits for sustainability in both approaches.

In a big picture, everything is tightly interconnected and depends much more on the user's daily "small" decisions than a pre-designed scenario. Someone could use Dream Bear duvet cover outside to tell stories about the forest in the actual woods or Sunny Sunday picnic cloth indoors as a couch cover, play rug or a decoration. What an item itself can do is to share transparent information about the background and manufacture of the textile and application, to assure that people who make these daily decisions are aware of the resources used to bring the solution to them. They choose to support the sustainability approach or not.

A common approach for fashion sustainability is to strengthen the emotional attachment between garments and the users. The cloth is expected to stay in the house longer because of the meaning it carries – the relationships it represents. It is beneficial as long as the approach keeps the material in use. However, the fact of storing textiles at home does not make them more sustainable. The textiles are produced and the resources are put into use, to get the benefit that the item can offer while being used. It has a different impact whether the garment has been in use or stored in a closet for an amount of years. It carries the highest benefit to the environment when the already existing cloth removes the need to buy a new one. Therefore, perhaps the challenge is how to transfer the meaning and the emotional attachment between different people, to make sure that the item is used to its maximum.

Leasing models proposed by the sustainable directions and expert interviews for the cloth carrying the digital stories could be a way to introduce a new type of hybrid product-service to the

market. Since the first scalable smart textile services are still being created; the standards for the area and care are also still developing. Therefore, thinking about what is sustainable and ethical is essential. Textile products need to be designed to last longer (SQ4 durable) while being in constant use (SQ7 usable), and growing together with the user and the culture (SQ3, SQ6 adaptable) with the help of technology. The conscious products or service systems need to give maximum experience for minimum resources while raising material awareness (AQ1 slowing, SQ2 reducing). The open and meaningful (SQ5 creative) textile applications build towards stronger societal relationships (SQ8 connecting).

While developing the sustainability qualities and the accompanying projects, some questions arose. How to transfer the intangible sustainability values from the designer to the user, especially if there is an independent producer in between? How could a smart textile service inspire the users for a more sustainable use: to consume less, to care for the items and to gain the maximum value out of minimal material use? How to inspire more circular business models to appear in fashion and especially the smart textiles field? What role could the developed sustainability qualities have in it?

The re-design took place only for the Bedtime Stories project because that was the only project evaluated by both craft and sustainability experts. When craft qualities were explored in different iterations of the same project, the sustainability qualities were formed by looking into three projects with their unique levels of integration of textiles and technology and envisioned users. Therefore, the craft qualities found in the Muhu skirt, QR-coded Embroidery, and Bedtime Stories and sustainability qualities found in Bedtime Stories, Vibe-ing and Thermocraft overlapped in one project — Bedtime Stories Little Red Riding Hood.

Last longer


Constant use

Growing together

Material awareness

Societal relationships



 Scan the image with the Textales LRRH app!

CHAPTER

6

TOWARDS THE FUTURE OF 6 CRAFTED SUSTAINABLE SMART TEXTILE SERVICES

This chapter summarises the main findings and implications of the studies described in previous chapters of this dissertation. It offers a reflection on the craft (Chapter 4) and sustainability qualities (Chapter 5) towards the future. The qualities identified and refined through the iterative RtD process (Chapter 3) in smart textile examples (Chapter 2), applicable to products and services, are presented as material, meaning, time and connections-related qualities with their main insights, implications and possible future uses. The chapter gives insights about what the craft and sustainability qualities share, and how they complement and conflict with one another. It discusses how to use the four themes emerging from the two sets of qualities for the future development of sustainable products and services. The impact of the work is discussed in the context of applying the craft and sustainability qualities in commercial projects. As such, this chapter integrates the previous chapters, and serves to answer the central research question in this dissertation (Chapter 1): what are craft and sustainability qualities and how are they implicitly used in the design of smart textile services? Finally, this chapter describes the future of the design projects, crafts in the modern world through other works, and gives an overview of what the work brings to the society.

CRAFT AND SUSTAINABILITY QUALITIES 6.1 FOR PRODUCTS AND SERVICES

Previous chapters identified and refined the craft and sustainability qualities in smart textile services. The qualities were implicitly used in the design of smart textile services. This chapter divides the craft and sustainability qualities in product-related qualities and service-related qualities (see Table 5) to provide knowledge that designers and design researchers could apply in other domains. While material-related qualities are relevant to product; meaning and stories related qualities, time-related qualities, and connections-related qualities link to the intangible aspects, and therefore – services.

Table 5 Craft and sustainability qualities, applicable to products and services, grouped into four themes.

THEMES	
Product-related qualities	Material-related qualities
Service-related qualities	Meaning and stories related qualities
	Time-related qualities
	Connections-related qualities

CRAFT QUALITIES	SUSTAINABILITY QUALITIES
CQ1 Embedded Meaning	SQ1 Minimal Material Consumption
CQ2 Material as a Medium	SQ2 Minimal Use of Energy and Chemicals
CQ3 Hidden Stories	SQ3 Ongoing Development
CQ4 Heritage and Tradition	SQ4 Long Lasting Care
CQ5 Touch and Feel	SQ5 Support for Creation of Meaning
CQ6 Societal Responsibility	SQ6 Updates for Personalisation
CQ7 Family Connection	SQ7 Platform for Positive Emotions
CQ8 Open Source Community	SQ8 Empower Relations
CQ9 Evolution in Time	

Each craft and sustainability quality has its unique angle to look into a certain theme. Even if they seem to be about the same matter, they unlock a different view to it. The four themes put qualities that deal with similar topics next to each other to point out how they approach the topic from different starting points. Issues such as what the qualities mean in relation to one other, how they depend on each other, and the interconnected dependencies between them are pointed out.

MATERIAL-RELATED QUALITIES IN PRODUCTS 6.1.1

The material-related qualities that put the physical material and environmental sustainability of the product forward appear in two craft qualities and three sustainability qualities (Table 6). CQ2 Material as a Medium that allow different stories to be told on a same material depends highly on the CQ5 Touch and Feel, which allows the material surface to become an interface for the user interaction. SQ1 Minimal Material Consumption, which values using items for longer period instead of exchanging them, goes hand-in-hand with the SQ2 Minimal Use of Energy and Chemicals, which helps the user to consciously make energy-efficient decisions concerning the product. None of these, however, would have much impact without the SQ4 Long Lasting Care that has its focus on the product's durability and care-taking aspects.

Table 6 Material-related craft and sustainability qualities.

Material-related qualities	
CRAFT QUALITIES	SUSTAINABILITY QUALITIES
CQ2 Material as a Medium	SQ1 Minimal Material Consumption
CQ5 Touch and Feel	SQ2 Minimal Use of Energy and Chemicals
	SQ4 Long Lasting Care

CQ2 Material as a Medium speaks to the viewer or the user. The product has embedded meaning and a story to tell about the natural and man-made environment of its origin. Pre-industrial crafts were practised locally. The materials and skills travelled slowly and therefore the material properties of items could refer to a story from the environment and from the craftsman. The Muhu skirt originating from a small island in Estonia, for example, carries a story in its orange-yellow colour yarns about the sea mines in the local port where they were dyed (Puppert, 2011, p. 159). The craft items reflected the present time, always developing and changing according to the new resources, technology, and skills becoming available. In the smart textile example, Textales Dream Bear reflects the current technology-driven era, where everything is in constant change and people need to keep up with what Bauman (2011) describes as the liquid modern world. The textile, being a reference or a window to an ever-changing digital world, is made to last. Therefore the static high quality duvet becomes a symbol of stability and the medium for telling and experiencing different stories in time. The Dream Bear could have spring, summer, winter, and autumn adventures as well as different special events for national holidays, family celebrations, etc. on the same cloth. The user becomes a craftsman, framing and expressing the story in a way that carries the values that are of high importance to the family and society. In the Textales Dream Bear edition, the user can work with the provided 3D and narrative material. In Textales Sunny Sunday edition, the end users form the cultural code and visuals to create the digital world. The users frame the story to be relevant, as a craftsman dealing with current topics.

CQ2
Material
as a
Medium

The material is described in this work as a combination of cultural and personal history in a mix with textile and technology, and it becomes tangible through the smart textile examples introduced in Chapter 2. The projects share an appreciation for touch, without which the material would not act as a rich medium carrying and communicating personal and cultural information in several layers.

CQ5 Touch and Feel is about appreciating the tactile properties of materials while making and using the objects. They invite touching. Each material, technique, and finishing feels different. The source material and techniques used for preparing the fabric can be experienced with the body, primarily by the hands. “When one touches an object, the touch searches for a connection between the object touched and the consciousness of the person who touches it” (Nimkulrat, 2012a, pp. 7-8). The touch forms the object, while the object communicates the previous touches embedded into it to the one touching. When I touch a mitten, I feel the work of a knitter, pattern maker, yarn dyer, spinner; the one who combed, picked, and washed the wool. Also I could not be touching the mitten without someone shearing and actually raising the sheep. To celebrate that appreciation for a touch, with all the worlds it conceptually (and physically) connects, the smart textile example Textales Dream Bear primarily depends on the feel of the textile. The characters on the Augmented Reality layer can only be interacted with via the physical textile. When the cloth is touched and manipulated, the Augmented Reality objects also move along. They can react unexpectedly and even more dependently on the textile, to generate more surprises in later versions of Textales. Both Textales Dream Bear and Sunny Sunday editions work on a high quality woven textile, made in the Netherlands. The digital interaction depends heavily on the textile properties and limitations. The user forms the textile material to interact with the digital world. He or she interacts with the digital world through the textile.

CQ5
Touch
and
Feel

The craft qualities Material as a Medium as well as Touch and Feel acknowledge high quality in making and interacting with materials, and the meanings and messages they conceptually or literally carry. The sustainability qualities Minimal Material Consumption, Minimal Use of Energy and Chemicals and Long Lasting Care, on the other hand, deal with the materialistic and physical properties of the same items.

SQ1 Minimal Material Consumption is about slowing down consumption. The quality is in experiencing maximal value using the minimal material resources. By introducing smart textile services, the textile material consumption can be expected to decrease, especially if the proposed concepts allow the same cloth to be used in different ways over a longer period of time. For example, the property of facilitating several stories on one textile in Textales Dream Bear could encourage users to keep their duvet covers longer. The same principal could be of course applied to any type of clothing. On the other hand, a smartphone or a tablet device, which previously had nothing to do with a textile, now becomes a “key” to unlock the information embedded in the cloth. Therefore, it is essential to pay attention to the existing devices people carry, and make sure the newly developed applications would be compatible with them. The users can keep their existing items and “refresh” them with new digital content rather than buy new ones.

SQ1
Minimal
Material
Consump-
tion

While the Minimal Material Consumption assures that the users would consume fewer physical items, the Minimal Use of Energy and Chemicals encourages the consumed items to be produced and cared for (washing, drying, etc.) with environment-friendly machines and materials. Minimal Material Consumption is about the products as items, and the Minimal Use of Energy and Chemicals an essential indicator throughout the production process as well as the use phase of the products.

SQ2 Minimal Use of Energy and Chemicals is about making choices for the product to use minimal energy and chemical input within its production and use phase. To be aware of and to minimise the use of energy and chemicals in the product’s production and use phase is essential for environmental sustainability. The energy as well as the fertilisers, pesticides, and chemical dyes used throughout the life cycle of a cloth should be monitored and documented, so that the user can be aware of what the product contains. Additionally, the user should hold sufficient in-

SQ2
Minimal
Use of
Energy and
Chemicals

formation for maintaining the textile at home or with a service provider with minimal environmental impact. On the digital side, Textales Dream Bear edition application works offline and only needs the Internet for downloading updates or new versions of characters. Therefore, the user can save energy consciously.

Even if the materials, energy, and chemicals have been used consciously in a minimal way (SQ1, SQ2), the items need very careful and knowledgeable care to last longer and to deliver the benefits from the craft qualities, such as Material as a Medium and Touch and Feel.

SQ4 Long Lasting Care is about providing durable materials (both textile and software) and concepts that can last. To contrast the trend-driven fast fashion items often designed only to last or a short time, Textales Dream Bear and Sunny Sunday editions are woven into a durable high quality textile material. The quality of the material, however, can only go half way. It needs to be maintained carefully to support its longevity. Therefore, along with the beautiful cover and picnic sheet, there is a care label with information about the product and how to care for it. In the future, leasing and reusing/recycling models could become beneficial to ensure the material would be used to its full potential by the user.

SQ4
Long
Lasting
Care

All the prior craft and sustainability qualities within this theme would need to be implemented in a textile product to be meaningful and sustainable. However, meaning needs time to build up, new memories are embedded in the material through touch all the time. Long Lasting Care is essential to allow the minimal material consumption and minimal use of energy and chemicals having an impact. People need to be able to use the items for an extended period of time while maintaining their high quality, comfort, and looks. The material-related qualities relate mainly to the environmental sustainability concerns.

The material-related qualities from the sustainability qualities side can be used for planning sustainable production for products. They refer to minimal use of resources during the product’s life cycle. The material-related qualities from the craft qualities side are more beneficial for quick and easy brainstorming about the possible processes supporting the value of the materials used in it. They encourage items to be built with the intention of interaction through touch. The material-related qualities can also remind the designer how the look and feel of the physical material is able to communicate messages of different levels, and how it needs to be continuously taken care of.

Production

MEANING AND STORIES RELATED 6.1.2 QUALITIES IN SERVICES

The meaning and stories related qualities, which put the user in the central role of generating emotional value in product service systems, appear in three craft qualities and one sustainability quality (Table 7). CQ1 Embedded Meaning puts the user into the position of a craftsman to share his personal experience through a product’s story. This expression of uniqueness creates the opportunity for the CQ3 Hidden Stories and CQ4 Heritage and Tradition to appear in Textales. In the CQ3 the user can continuously give new meanings to the story he shares and with CQ4 he passes it on in the family. The sustainability quality SQ5 Support for Creation of Meaning builds on the previously mentioned craft qualities, in which the user can materialise and share stories that carry his values through services.

Table 7 Meaning and stories related craft and sustainability qualities.

Meaning and stories related qualities	
CRAFT QUALITIES	SUSTAINABILITY QUALITIES
CQ1 Embedded Meaning	
CQ3 Hidden Stories	
CQ4 Heritage and Tradition	SQ5 Support for Creation of Meaning

CQ1 Embedded Meaning is the “coded” tacit knowledge the maker gives to the object. It is about telling the story of the craftsman and how it becomes part of the item. It can be well known within a group or it can be personal, expressing uniqueness. Folk costumes carried different types of “coded” information that only the dedicated community was able to read and understand (Summatavet, 2005). The community in which the item was made embedded its traces by the colours and materials used in the item. The craftsmen, however, told their personal stories through the items they made by adapting universal symbols to communicate the topics currently relevant in their community. They also created personal signs to leave traces into craft pieces. Intentionally or not, each craftsman had an individual style or signature. In a similar way, as the community embeds its influences in the folk costume, Textales Dream Bear carries elements for a story prepared and illustrated by a local storyteller and the rest of the project development team. It is up to the parent or siblings of the children listening to the story to craft a personal meaningful version of the story based on the provided content. The story is “coded” on the beautiful illustrated duvet cover and can be unlocked by the use of imagination of the family or the Textales tablet application. The end user, telling a story to his children or siblings, shifts from being an external user and listener, part of the society, into a central position of being the craftsman working with the material, having to embed his meaning and experiences into the storytelling. In the Sunny Sunday edition, the end users create the digital content for the application, thereby having a more tangible outcome from their work with the material. However, creating a meaningful story experience through the combination of textile canvas and provided 3D fairy tale characters allows the storyteller to craft a new experience each time. The user embeds his meanings and experiences into the story as a craftsman into the items.

While Embedded Meaning activates the craftsman in each person, giving them an opportunity to create and share their personal concepts, the Hidden Stories allows those expressions to be experienced by other people and the community. It creates another bridge of translation between the user, embedding their story into the item, and the viewer interpreting the meanings in his context. That transition transfers the craftsmanship approach from the one embedding the meaning to the one interpreting it in the context of his community.

CQ3 Hidden Stories represents the narratives attached to certain materials and objects, either in imagination or in technology. Traditional folk costumes used to carry public and personal information embedded into them. The clothes lasted for a long time; therefore, even though the symbols and colours were woven or knitted into the fabric and costumes, the “code” for how to read and interpret them could change over time. Muhu embroidery has always been connected to the times, conditions and people of the time, and developing together with the island and its stories

(Kabur, Pink, & Meriste, 2010, p. 295). The colour, cut, or patterns of the clothing and also the way certain items were worn could reveal different personal information about the wearer. The information, however only existed in the understanding and imagination of the person looking. The way to give meaning to the details was embedded by the culture and surrounding community. The local storyteller involved in the project hid some stories about the animals in the forest part of the tale about a dream bear into the Textales duvet cover. The smartphone or a tablet with the Textales application becomes the common thread connecting the community of viewers in this case. The application translates the images to markers, and markers to digital content, which it shows in the Augmented Reality layer on top of the cotton textile with a beautiful forest setting. As the final meaning about the folk garments, the true story of Dream Bear is influenced by the person telling the story and his cultural and personal background. The same story can be understood and interpreted in many different ways. Each family understands the adventures of the Dream Bear in the light of their past and current experiences. Similarly, in Textales Sunny Sunday edition, the same symbol on a picnic cloth could relate to a different emotion for a different friend. Each event can be experienced in as many ways as many people were involved in it, perhaps in even more ways, since the understanding could change in time. Therefore, even if the technology makes a certain narrative or a character “tangible” in the digital layer, the underlying personal meaning that it has to the user still hides in his imagination. The user, as part of the community of the craftsman, can continuously give new meanings to the story told by the application, and look at it from different angles.

While Hidden Stories is mainly about the community, which finds and gives meaning to the work and information embedded by the craftsman, Heritage and Traditions goes back to the craftsman and allows him to transfer his experiences to the community or family line.

CQ4 Heritage and Tradition is about passing on knowledge, to share the life lessons as stories. It was an essential part of a daily life to learn handicrafts and to practise the perfect loops and weaves in a pre-industrial family. Mothers had to teach soft craft skills to their daughters (Summatavet, 2005) and fathers hard crafts to their sons. More difficult work methods could be learnt from an actual master of the specific craft in a workshop (Sennett, 2008). As crafts evolved, so did the lessons given to practise them. Perhaps each mother carefully transferred her own particular way of practicing the certain handicraft, so it could evolve in later generations. For example, Textales Dream Bear edition communicates the involved storyteller’s passion for camping and animals through the story elements. The story leaves freedom for the user - the parent or sibling - to present their unique version of the pre-made story. They are encouraged to add and to communicate their own experiences and values to the narrative while experiencing it with the listening and interacting children. It is a conscious choice to use a contemporary new story, and not a fairy tale originating from hundreds of years ago in Textales, to make sure it speaks to modern parents and children and that they can easily relate to it. It is about translating the traditional fairy tale values into a modern language. The aspect of sharing stories through the interaction between the textile and Augmented Reality visuals allows the content to be shared in a new way. It encourages the families to “touch” the imaginary and create stories together. The users pass on their values and knowledge to the children through the interactive storytelling.

Craft qualities in general depart from more societal and intangible ideas as compared to sustainability qualities. Therefore, it could be expected to find more meaning and story-related qualities among craft qualities. Support for Creation of Meaning builds on the previously described craft qualities in a more practical way. While embedded meaning and hidden stories to carry heritage and tradition is a rather intangible notion, which could be interpreted and applied in different ways, the Support for Creation of Meaning brings it together in a solid way, describing what the

CQ1
Embedded
Meaning

CQ3
Hidden
Stories

CQ4
Heritage
and
Tradition

smart textile service should deliver.

SQ5
Support
for
Creation
of
Meaning

SQ5 Support for Creation of Meaning is about providing an intuitive and simple platform for the users to share and communicate their values. The service elements of the product should be clear and simple. Textales Dream Bear edition invites the users to exercise their creative storytelling skills and motivates them to create meaning with and within the family. The user can always cut, sew, glue, etc. the cloth to change the canvas of the story. The application of Textales Sunny Sunday allows the user to create any digital content and attach it to the picnic cover. Perhaps the leasing model could even motivate physical changes on the canvas by offering more benefits for people who have customised their cloth the most. It would be more difficult to return that modified cloth to the service cycle, however the users embedding their meaning and work into the cover are also less likely to get bored and return it in a short time.

The sustainability quality Support for Creation of Meaning can be realised through the craft qualities presented in this theme. While the described sustainability quality guides the product and service, the craft qualities describe the content it should carry. Both need to complement each other to deliver a meaningful and sustainable smart textile service. The meaning and stories-related qualities relate mainly to the cultural aspects that are part of the societal sustainability.

Meaning and stories-related qualities from both the sustainability and craft qualities sides can be used for thinking about possible related services making the product act in a meaningful product service system. They encourage personal and cultural experiences and values to be carried along and kept close to the people in the items they use.

6.1.3 TIME-RELATED QUALITIES IN SERVICES

The time-related qualities, which allow the surrounding community to participate in the evolution of the service, appear in one craft quality and in two sustainability qualities (Table 8). CQ9 Evolution in Time allows the user as a craftsman to continuously add his new life experiences to the story of using the product and therefore make the product evolve in time as he does. SQ3 Ongoing Development is more about the service provider concerns, to keep the product up to date and always modern. SQ6 Updates for Personalisation brings the focus back to the user as the craftsman, who can adapt the elements of the story to fit the user's personal views and preferences. While CQ9 is about the stories and intangible experiences that the user can communicate through the stories and symbols, the SQ6 is about the symbols themselves and how even those can be adapted, changed, deleted in time.

Table 8 Time-related craft and sustainability qualities.

Time-related qualities	
CRAFT QUALITIES	SUSTAINABILITY QUALITIES
CQ9 Evolution in Time	SQ3 Ongoing Development
	SQ6 Updates for Personalisation

CQ9 Evolution in Time is linked to the constantly changing world. It is about allowing the items to change in time with people. Crafts change continuously. They develop together with the craftsmen applying new techniques and technologies. If they do not change they stagnate. Bardzell, Rosner and Bardzell (2012) argue that craft is not a dead skill from the past to be preserved, but rather that craft participates in everyday life and evolves over time. Crafts gradually change due to environmental, material, or mindset changes in the community and in the craftsmen. Textales Dream Bear encourages the user to adapt the story they tell to their children from time to time. The makers can send new characters and updates to the people telling the story. The families can also download a new story to experience on the same forest setting textile. They might want to do that when the child gets older and needs a different story, or just to get fresh ideas and stimulation for their story creation. Textales Sunny Sunday edition also changes in time. No group of people is static. The characters and the story are in constant development to keep up with the real life changes. Friends move to other countries, some get emotionally distant, some closer, new friends appear. It's a constant change and the platform allows it to be seen as a natural part of life. Moreover, the freely available and open source platforms don't guarantee sustainable service. With Textales Sunny Sunday edition, I had to change the platform already while developing the project due to the first choice becoming unavailable. The users as craftsmen can continuously add their new experiences to the story and therefore make it evolve in time with them.

CQ9
Evolution
in Time

Allowing the user to apply his creative craftsmanship qualities, the smart textile service develops along with him in time. That allows for a service model to grow from this interaction between the user and the application developers. While the craft quality Evolution in Time focuses on the user and his changing needs, the sustainability quality Ongoing Development points out the need to continuously develop the product, preferably as part of a service system.

SQ3 Ongoing Development is about a service system that allows the software and support for users to be up to date. The ability to adapt to the user over time is an important property of a long lasting item. The meaning of materials and products changes in time due to passing trends and experiences, which familiarise people with certain symbols. And that emotional tie to a product could be enough to keep it longer in use; however the digital application in Textales Dream Bear brings an extra layer of information on top of the textile, which continuously changes in time acting as a service. The same forest can host bears, rabbits and robins one day, and an entirely new family of animals in the next one. The application should always be compatible with older and newer devices, so that the user can easily take the story with them when changing their smartphone or tablet.

SQ3
Ongoing
Development

Ongoing Development ensures the smart textile product and service is always up to date and provides current and relevant experiences to the user. Updates for Personalisation places this in the user context, enabling them to create and update the relevant content.

SQ6 Updates for Personalisation is about the way users can update the textile product through adding and adapting digital content.

SQ6
Updates
for Personalisation

Personalisation creates meaning, therefore this quality links closely to the SQ5 Support for Creation of Meaning. While Support for Creation of Meaning is more focused on the users' freedom to create content of any form they would desire, the Updates for Personalisation appreciates the possibility that both the material/product and the service providing content will change in time. The user or the service provider adapts them. As the child grows, the family needs different stories on Textales Dream Bear cloth. The Textales Sunny Sunday cloth invites the group of friends

to add textile and other physical materials to the cover to customise and update it as they are also encouraged to do online with the digital content.

Since the world is complex and constantly evolving, it benefits from products and services that are dynamic and able to adapt to the users and the new situations ways of working, meaning creation, etc. The evolution in time acknowledges the user to be in continuous change. The Ongoing Development and Updates for Personalisation qualities support that never-ending transformation process. The time-related qualities relate mainly to the service models and the economic sustainability.

Time-related qualities from both the sustainability and craft qualities sides can be used to envision products and services that can adapt in time to suit the user's changing needs. Products that can be quite static might be changed or adapted in time through services.

6.1.4 CONNECTIONS-RELATED QUALITIES IN SERVICES

The connections-related qualities, which touch the community in a larger sense and step into societal values, appear in three craft qualities and two sustainability qualities (Table 9). It's about the service system. While CQ6 Societal Responsibility is more concerned with a larger picture and making people aware of what and whom it involves to get the product to them, the CQ7 Family Connection is about nurturing and strengthening relationships within families through imagining and creating together. The concept of family can be seen on a smaller or larger scale from immediate relatives to friends to community or even society. CQ8 Open Source Community values and builds on the work of others in the same (virtual) community. It allows the user to interpret the provided service in his own way, communicating his personal values through it. SQ7 Platform for Positive Emotions allows that personalisation to happen through supporting content creation and modification. SQ8 Empower Relations brings all the previous aspects together to share and communicate. It encourages the project partners and users to learn and to get to know each other and the different encountered experiences while enjoying a playful interaction through the material and the product.

Table 9 Connections-related craft and sustainability qualities.

Connections-related qualities	
CRAFT QUALITIES	SUSTAINABILITY QUALITIES
CQ6 Societal Responsibility	SQ7 Platform for Positive Emotions
CQ7 Family Connection	SQ8 Empower Relations
CQ8 Open Source Community	

CQ6 Societal Responsibility directs attention to the materials and people who are part of the production and delivery process of the service. They need to be treated fairly. Pre-industrial craftsmen had distinguishable styles in their work, which made it possible to trace a craft object back to its maker. Each location had its natural resources for materials and certain ways of work-

ing with typical styles and patterns nurtured by the local community. The item's making process formed a story with its embedded meaning in the specific community (Kabur et al., 2010). The materials scarcity and local lifestyles allowed nothing else than local and high quality materials and production. Today, the textile and garment production chains are long, distributed and global. For practical reasons, it becomes close to impossible to produce larger series of textile items locally with one provider from the raw material to the packaged products. The specialties are spread all around the world. For example, we sourced work and materials from India (yarns), the Netherlands (weaving and software development), Estonia (cut and sew) for the sample series of Textales Dream Bear and Sunny Sunday editions. The origin of each work and material are made public in order to raise awareness about the complexity of the combined production steps. The users, as craftsmen, become aware of the origins and people involved in bringing the innovative product to them.

While the societal responsibility puts larger view to the society into the attention, designers need to be aware of the work conditions outside their country of work to evaluate whether sourcing the production to a certain factory is socially responsible or not as well as to ensure fair pricing. It is mainly about social relationships and treating every actor in a long line of garment production with respect. Family Connection focuses on a different type of interaction. It brings the families and communities closer through creative common activity.

CQ7 Family Connection values the time shared within groups or families while making and creating together. It represents the stories that were shared during crafting activities in pre-industrial families. People lived closely together, and the sunset hour was cherished for sharing experiences from the day. Women also used to gather to make belts, mittens, socks, and other textile work for wedding ceremonies and dowries. The objects were important symbols of the transformative events (wedding, funerals), but the stories that were shared while making those had a role as well. Group connection through crafting has also been used in therapy (Corkhill, 2014). When the hands are busy, the mind can wander and reach places the busy mind cannot go. Textales Dream Bear edition encourages families to share their stories through a premade forest camping setting and animals. The parents and siblings can use the characters in their narrative to touch topics important at the moment. Textales Sunny Sunday shares the stories of a group of friends. Over time and distance they made characters and other digital objects that are part of the ever-changing narrative of their friendship. Today, I touch interfaces to the digital world, such as a mobile phone, keyboard and a computer mouse more often than a crochet or knitting needle. I want to explore how the new tools and craftsmanship can bring meaning and reflection closer to the daily life of people. The story of Dream Bear has a narrative, however it still requires the parent to exercise his imagination and to be the craftsman to deliver it in a meaningful way.

While Family Connection suggests a closed smaller group of activities creating intimacy and tight bonds, the Open Source Community contradicts it, by sharing the knowledge and created stories with the community. It values the benefits of building on each other's work and acknowledging the links between them.

CQ8 Open Source Community is about creative use of global resources locally. It is about an item becoming a platform of shared making. Within a closed community, the craft knowledge was open. Kabur, Pink and Meriste explain that the driving principle behind Muhu women's production of domestic textiles was "to make one's clothing as fine as the finest garment of one's home village, and even a little bit better" (Kabur et al., 2010). The styles and inspiration were also borrowed and adapted from other communities' creations. They got applied to the local context and relevant issues. For example, the young women of Muhu island, who worked on

CQ7
Family
Connection

CQ8
Open
Source
Community

the mainland of Estonia, brought some patterns and colours from the tapestry of the houses they worked in into the Muhu embroidery (Kabur et al., 2010). Textales Dream Bear edition provides a narrative and characters illustrated by a storyteller from the Netherlands. The story, however, is open to change its course. It can follow different paths and have extra adventures added by the parent. Therefore, it becomes a textile canvas for sharing stories through Augmented Reality or otherwise. It allows the family to craft their own story providing some inspirational elements as a starting point. Textales Sunny Sunday edition is on the other hand built entirely by the group of people sharing the story amongst themselves, using an open platform to connect their digital creations to the Augmented Reality on the textile. In both cases, the textile carries a modern story told by the community of makers and storytellers, who use creativity, as craftsmen, to bring it to life.

Open Source Community creates stories from and to the community. The sustainability quality Platform for Positive Emotions provides the platform for doing it. Therefore the Family Connection and Open Source Community both depend on the Platform for Positive Emotions.

SQ7 Platform for Positive Emotions is about keeping the service easy to approach and allowing the users to create content as freely as possible. Usability has an important role in the emotions people experience while interacting with an item. For example, the Textales Dream Bear cloth is comfortable and beautiful. The application is simple, clear and intuitive for the user. The technology is in the background and the story has the central role and all the attention. The Textales Sunny Sunday allows any kind of digital content to be attached to its physical picnic cloth. The users are free to customise the textile as well as create, modify and remove different types of digital stories connected to it.

Platform for Positive Emotions supports the Open Source Community and Family Connection. All of the previous relations within the society, family and community are made as a central carrier of the Textales smart textile application. The relationships are nurtured by the Empower Relations sustainability quality. It ensures the interaction between the people is the driver for the product or service.

SQ8 Empower Relations is about keeping the interaction within families or groups as the primary driver of the concept. Textales Dream Bear and Sunny Sunday editions focus on nurturing the relationships within families and groups or communities. The adventures of the dream bear only take shape with a parent or a sibling creatively connecting the premade characters to the daily life and personal context. It becomes a mean of communication for the family, supporting their interaction with a comfortable textile surface for it. Textales Sunny Sunday is about valuing and symbolising specific experiences uniting the group. For example, in the centre of the cloth is Guille's house, who hosted the group of friends one Sunday from midday pancake brunch until the late sunset of that summer day on his balcony. The mutual experiences and shared stories build up the content for Textiles.

The craft quality Societal Responsibility, as the overarching umbrella nurturing connections all over the world, connects closely with the sustainability quality Empowering Relations, which acts on a more intimate level connecting people through creativity in families and communities. The craft quality Family Connection is very similar to the latter, valuing the connections created while working together on the family level. Platform for Positive Emotions allows the product or service to be the mediator for the previously described connections. Open Source Community allows the knowledge and creativity between all the groups and individuals to be shared and built upon. The relations related qualities are mainly concerned with the societal aspects of

sustainability.

Connections-related qualities from both the craft and sustainability sides could be used to envision respectful networks of working together as opposed to unequal production chain hierarchy. Different disciplines working together towards a mutual goal or service while sharing their knowledge build a healthier society. The qualities also allow for family and community relationships to be in the centre of the services developed.

IMPACT 6.2

This section looks into how could the designers and design researchers in the smart textile and other fields use the craft and sustainability qualities. Examples from working with the material illustrate different phases of the craft and sustainability qualities that were used during the design projects. The efforts toward commercialisation and the related ideas, with the future of the design projects are described. Finally, the chapter concludes with a reflection into the topics raised in the introduction. What did the research bring into the world?

APPLYING THE CRAFT AND SUSTAINABILITY QUALITIES 6.2.1

The sustainability qualities are based on the tangible products such as duvet cover, picnic cloth, and mobile or tablet device, digital platforms and life cycle considerations, while the craft qualities are based on more intangible characteristics of services, such as emotions, meaning, relationships and culture. The intangible characteristics arising from craft qualities such as embedded meaning, heritage and tradition, societal responsibility, and family connection are relevant when working on the design and interaction aspects of products or services. The craft qualities convey ideas on how to develop meaningful smart textile services. In the design projects they were used to evaluate whether a certain feature should be part of the design, and to gain additional ideas for the interaction the project should support. For example, while developing the Digital Stories on Textile (2.1) project, the possibility of adding buttons and other interaction elements to the tablet screen came up. Those proposals were immediately neglected, referring to the importance of the touch of the textile material itself (CQ5 Touch and Feel). Therefore, the digital characters only react to the changes of the cloth. I often turned back to the qualities during the development of the projects, to focus on the direction and evaluate how the new development directions fit the craft qualities. The craft qualities supported the envisioning of the service models from the user point of view, as they deal mainly with the human elements in the service system. The intangible characteristics can support the ideation and development processes of designers. To approach a topic from the crafts point of view, it is automatically societal and closely linked to the community, personal sphere, and the material within a cultural context.

The tangible aspects arising from the sustainability qualities, such as minimal material consumption, use of energy and chemicals, and long lasting care, are more beneficial for setting up industrial production. These qualities help one to think strategically about the commercial side of the spectrum of developing smart textile services. They are tangible and give pointers for better production methods and service ideas. For example, I turned back to the sustainability qualities while developing the requirements for producing the application as well as the duvet covers for Textales project. The qualities guided me to choosing business models that would fit better the project within the sustainability value system. The sustainability qualities could be more compat-

ible with the viewpoint of the producer and the service provider.

The combination of craft and sustainability qualities is beneficial for designers who would like to develop craft inspired services that resonate with sustainability principals, as seen from environmental, societal and economic points of view. The material-related qualities (6.1.1) look at the physical textile and electronic materials and relate to the environmental sustainability aspects, whereas the craft qualities within the group act more as inspirational input for concept and content development, while the sustainability qualities in the theme give pointers for production and further maintenance during the use phase. The meaning and stories related qualities (6.1.2) focus on the user and relate mainly to the cultural aspects, which are part of societal sustainability. The craft qualities within that group can inspire or guide decisions, when choosing new directions within design projects. The sustainability quality mainly gives pointers for the product's usability. The time-related qualities (6.2.3) involve the community in creating meaning through interacting with the smart textile, therefore relating mainly to the service models and the economic sustainability. The craft qualities in the group again serve more for inspiration and guidance for the ideas around the user and content. The sustainability quality provides insights for the possible service or business model. The connections-related qualities (6.1.4) give a broader view to the whole ecosystem of users, community and society as a whole. They are mainly concerned with the societal aspects of sustainability. The craft qualities pointed out in this theme inspire and guide how to approach family, community and society related questions. The sustainability qualities of that group give more practical insights into how to apply those values.

If any smart textile product could be evaluated using the craft and sustainability qualities, they would most probably not have all the suggested areas covered. For example, a jacket with embedded heating system could encompass some of the material-related qualities, such as minimal material consumption and the minimal use of energy and chemicals. It could be designed with long lasting care and societal responsibility in mind. However, the rest of the craft and sustainability qualities could be used to design a service system the product would belong to. The product could become part of a maintenance and warranty system to provide ongoing development and evolution in time with personalisation possibilities. The jacket could carry meanings represented in temperature patterns, or tell stories about the places it has been by the way it has been heated. The activation of the warming elements could be related to the touch and feel of the materials, such as stroking, patting, pulling, etc. The jackets could connect people by allowing them to feel each other's temperature. Perhaps the warmth could be shared in networks, transferred from one person to other. All in all, the craft and sustainability qualities are beneficial for designing the physical items; however they are even more inspiring for the service element giving meaning to the objects. In my own work for example, by applying craft qualities and sustainability qualities to the Bedtime Stories (2.1.2) project while developing its following iteration Textales (2.1.3), it became explicit how important would be the role of allowing users to make and upload their characters and stories to the application.

When working with the craft and sustainability qualities, the technology developments also have to be taken into account. What might concern the designer today might not be an issue when envisioning future products and services. For example, at the moment, some of the concerns for sustainability in the smart textiles example Textales come from the use of gadgets through which the Augmented Reality is displayed. The qualities suggest designing for multi platforms and backward-forward version compatibility. However, in the future the devices could be shared, obtained freely, integrated into our clothing, or even bodies. Perhaps thinking in broader terms, the technology disappears. How would the craft and sustainability qualities then appear? Even if

the tangible product-related qualities would become insignificant, the intangible service-related qualities could still apply.

TOWARDS COMMERCIALISATION 6.2.2

The design portfolio developed in the growth plan setting (Wensveen, Tomico, Bhömer, & Kuusk, 2014) has gone through the incubation and nursery phases during the research, and has partially been adopted by the industry for commercial applications.

The current research did not look deep into the economic sustainability; however, this section reports on the first attempts to commercialise the smart textile project. The previously determined themes will be used to reflect on the craft and sustainability qualities as part of the commercialisation steps. Material-related qualities (MrQ), meaning and stories related qualities (SrQ), time-related qualities (TrQ) and connections-related qualities (CrQ) will be associated with certain actions and considerations throughout the process.

CROWD FUNDING CAMPAIGN TO EVALUATE THE CONCEPT & TEAM 6.2.2.1

The craftsmanship (Sennett, 2008) way of innovating carries potential for achieving culturally meaningful results. When an idea forms between a person and the material, being influenced and fed by the community around, it grows slowly and gets refined during the process (SrQ). There is no commercial pressure, and no marketing possibilities for finding a critical mass of people to let the innovation become a medium (Morris & Ogan, 2006). For an innovation to have an impact on the society, it needs to reach the people in it. Over the course of the project I have spoken about sustainability-related topics in the context of smart textile services. Magic-like textiles (SrQ), that are able to show little animated fairy tale characters, light up, vibrate, or change colour to catch attention, definitely provide an interested audience. However, to get further from the concept level, to actually implement some of the innovative sustainable-minded ideas, a critical mass of people is needed. The projects need users who would believe in such ideas, who would support the goals and provide means for sustainable smart textiles to be created and maintained in high end-user ready quality (MrQ).



figure 81 Bedtime Stories Little Red Riding Hood duvet cover and the 3D wolf from the story.

In the search for a like-minded community, which would support the ideas of achieving more sustainable textile products through the implementation of technology through the services, with the team of Digital Stories on Textile (2.1) Bedtime Stories Little Red Riding Hood (2.1.2.1) (Figure 81) we set up a crowdfunding campaign (CrQ). On 15th November 2013 we entered our proposal on Kickstarter (www.kickstarter.com), one of the largest crowdfunding websites, which was founded in 2009. People could support the project and get awards (Figure 83) in return in the case of a successfully funded project. It was the first time doing something like this for everybody in our team. Through the process all members of the team could refine their understanding and vision about the project. It became clear what needed to change in the dynamics between people as well as what kind of competencies were missing in the team. The valuable experience formed and refined our goals with the project. Below is a short reflection about the motivation to start a crowdfunding campaign (Figure 82), insights learned and what the team could bring along from such experience.

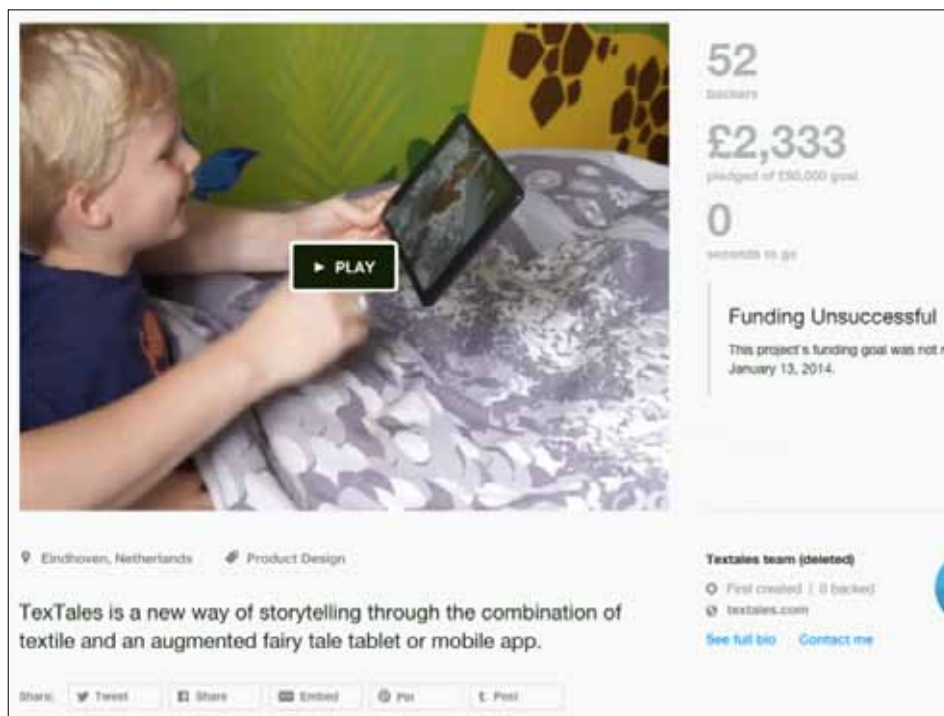


Figure 82 Unsuccessful Kickstarter crowdfunding campaign for Bedtime Stories Little Red Riding Hood.

One of the main problems with the fashion system nowadays is the enormous number of prepared garments that never get sold. As 30% of ready-to-wear gets neglected as a pre-user waste (Matevosyan, 2014), it does not provide inspiration for bringing new textile products into the world which might never find a user and a home (MrQ). Therefore, with the Bedtime Stories project, I wanted to make sure the bed linen would not end up in store drawers. I wanted to find a business model that would allow the textile products to be made, only if there was a user desiring them. The textile items would have only been produced on a made-to-order basis, where the production only starts when future users have ordered a viable number of products. This would have allowed us as the project team to produce individual order-based objects by mass production means and efficiency (MrQ).

Another strength of crowdfunding is the community behind it. Open-minded people who support the idea, would definitely be a driving force for developing the idea in other directions (CrQ). I was curious to hear their opinions, preferences and ideas in developing the next iteration of the project. People within the immediate community (friends, families, colleagues) as well as the society around shared the project with joy. They liked to talk about it. So why was the project not ready for realisation by that time?



Figure 83 Pillowcases and iPad sleeves were part of the awards offered for the Kickstarter campaign supporters.

During the campaign we learnt that to introduce a new type of material in a new project with a new way of thinking aiming for a new business model meant too many new things at once. We were not able to communicate the project clear enough, and it was difficult to understand the focus and clear output of our goal from the campaign introduction video (SrQ). It was a valuable lesson to try bringing one new property at a time to people. Once they get used to the material, we can introduce the product and so forth. There has to be a good story that is clearly communicated in the video to run a successful Kickstarter campaign (Purde, 2013). The target amount of the project was calculated based on the minimum quantities for it to be sustainable to run the facilities and machines for textile production and software development (MrQ). At that time, we could not make it into the range psychologically attractive to typical Kickstarter backers, which is between 1000 - 9999 USD (Zorn, 2014). Usually when a project reaches its target goal, it is when people start to write and share news about it. All in all, our project and the team were not ready for a Kickstarter campaign at that time. However, we learned valuable information and changed our course and directions based on the feedback received.

To arrange a short, yet intense, project such as a Kickstarter campaign was a great tryout for the project team. We could find out our strengths and weaknesses; and also, how the different people and disciplines work together in pulling such an effort forwards (CrQ). Our team could have benefited from having a person running the project full time, as well as marketing and distribution partners. The experience helped the team to fine-tune the concept, idea, and goals of the project. The directions to explore for the project crystalized. We understood the economic challenges and the importance of a clear simple story. It reminded the team of the risks of trying to realise and communicate many complex aspects for one end result.

I would certainly advise any new team and idea to be "tested" out on a crowdfunding platform. To be in immediate contact with the potential users and other people (CrQ) enthusiastic about the project helps to refine, focus, and validate it commercially. It clarifies whether the idea is focused enough, wanted in the world and attractive to talk about it in social media. These attributes are helpful for refining the goals or in case of a successful campaign, starting up the project. Any large number of products can be sold by good marketing and sales work; however, whether it is really needed is the question (MrQ).

6.2.2.2 SETTING UP THE PRODUCTION LINE: FROM 1 PROTOTYPE TO 10, AND TO 100 PRODUCTS

Participation in a crowdfunding campaign gave the team the opportunity to arrange and try out the possible production line. The software was already prepared for the Bedtime Stories project, and we did not need to alter it for the campaign. Simple examples, such as pillowcases, duvet covers, tablet sleeves (Figure 84) and mobile sleeves were prepared to demonstrate some of the possibilities for storytelling. The simple textile objects carrying Augmented Reality stories sounds like an easy hybrid product that does not need all the machinery and skills in the house to be produced. The software can be developed in one location and textile items in another with no major complications. Some unexpected extra steps and considerations occurred though.



Figure 84 The tablet sleeves made as samples for the Kickstarter project.

For the Kickstarter campaign, everything had to be prepared in a way that it could potentially transform into a larger production (MrQ, CrQ). Studio Toer, in collaboration with Unit040, designed the textile graphics to fit the concept and to be easily recognisable by the tablet application, which was developed by Unit040 in the Netherlands. Johan van den Acker Textielfabriek, also situated in the Netherlands, translated the digital design into a weaving pattern and produced the sample meters for the textile. The duvet covers, pillowcases, tablet sleeves, play rugs and smart phone sleeves were sewn in my hometown in Estonia. In the company established by my parents 24 years ago, I could closely follow the production process and the impressions of people working with it (CrQ).

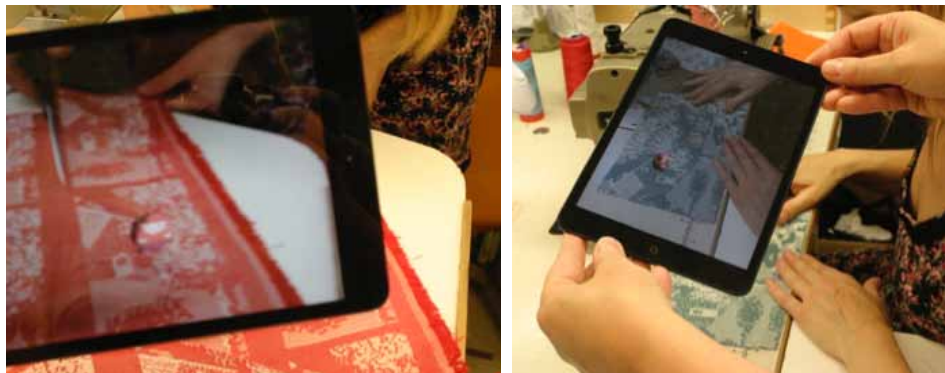


Figure 85 Looking at the 3D character through the tablet application while cutting and sewing the items.

The pattern makers, cut, and sew professionals, could work with the Bedtime Stories fabric as with any other. However, the added layer of Augmented Reality made them want to take out a tablet device from time to time, to see where and in which angle the digital character is located on the textile object (Figure 85). During the production, marks were placed on the textile where the digital characters would appear. It had to be made sure that the cutting and sewing would not interfere with being able to see the digital layer (MrQ). Especially with smaller items, such as tablet sleeves and smart phone sleeves, this issue was critical, as they had to be folded and some elements such as a rubber band on a tablet sleeve had to be added to the sleeve. All of this would be solved in product development phase.

During the cut and sew process, it also turned out that one of the sample woven fabrics, carrying the image in the size of the play rug, did not show the Augmented Reality layer on top of it. After some experimentation and thinking, we realised that the image had been woven in a mirrored way (MrQ). Therefore, the image recognition did not catch the marker that it was expecting to recognise. It raised questions about the quality check. In which step of the production should such fabric be checked through the tablet application view? (CrQ) Typically textile is checked for loose threads, holes, colour, or other defects as one of the last steps before leaving the fabric production facility. However, to check whether the Augmented Reality layer works as needed is not part of their regular control system. Most likely, the check should be performed in several production steps, to avoid investing the work of various people and discovering in the end phase that there is an issue with the pattern on the fabric that was not easy to detect by eye (CrQ, MrQ).

The technical issues appearing in the process of manufacturing can be solved with the process adaption and do not cause much trouble if caught in time. To add an additional quality check procedure would increase time needed for production and therefore influence the pricing of the material and products; however, it is not a difficult step to overcome. What surprised me during the production process, when first looking at the woven images in different scales next to each other on a long cutting table, was the way they scale the digital image according to the sizing of the pattern on the cloth. It's a logical outcome and could be seen while printed on a piece of paper as well, however, having a 2m by 1.40m fabric scaled into a size of a tablet sleeve changes the proportions considerably. This experience created new ideas and possibilities to play with the scale of the patterns and objects (MrQ).

If a prototype is meant to be scaled into larger quantities, it is beneficial to produce it by industrial machines as soon as possible in the development process. In the example of Digital Stories on Textile (2.1), already the first prototype QR-coded embroidery (2.1.1) was produced to have the potential of scaling up in mind. Of course the industrial processes for producing the objects with embroideries would have differed from my work on the TU/e machines, but not dramatically. The same was the case for the Bedtime Stories: the transition from one prototype to mass production was effortless, because the techniques and tools used were comparable. The process between the two first iterations of Body Sensing and Actuating Networks (2.2) from Felt Ball (2.2.1) to Tender (2.2.2) had a much larger gap to fill in materials, technology, and machines used. The first prototype was a handmade felted conceptual exploration, while the second one was produced on an industrial knitting machine. Everything had to be set up from zero for the production. It was a long process full of many trial and error cycles. Throughout the project there was a lot of manual work involved in integrating the electronic modules into the knitted pockets. In Thermocraft (2.3), the transition between the handmade iterations CHACUN(E) (2.3.1) and YB-ML (2.3.2) into the machine-made Butterfly Lace (2.3.3) went smoother again. Perhaps the crochet structure resembles the lace structure, which still remains very craft-like. The

traditional machines that were used to produce Butterfly Lace work on very similar principles to the hand bobbin lace making. However, the dyeing process remained manual and low quantity in the scope of this project (MrQ).

The three projects differ in their level of integration of textile and technology. It has an impact for the production as well. The example of adopted level of smart textile, where textile is separately functional from the technology and vice versa, Digital Stories on Textile, is relatively easy to produce. Traditional textile production methods and tools can process the textile part. Technology (iPad) is made separately and independently. The connection between them, the Augmented Reality software, needs to be adapted to the textile specifics, however software professionals can also do it in an independent location. In this approach each of the professional fields needs to adapt new knowledge and input from the other fields, but still use their well-developed skills, applying them in a new type of hybrid product (CrQ). The example of integrated level of smart textile - Body Sensing and Actuating Networks - brings conductive threads and wires as well as electronic components into a machine-knitted garment. The knit professionals had to experiment with machine settings and materials that could be used for several days before finding a workable combination to start developing the prototypes. The electronics industry is used to making custom-made electronic sets; however the step of integrating the electronic boards into the knitted garment remained a manual handmade step in our process. The example of combination level of smart textile, where textile gets merged with conductive threads and thermosensitive inks in Thermocraft, gets machine produced in a lace factory, however it needs the lace to be dyed and connected to the electronics by hands afterwards.

6.2.2.3 TOWARDS THE MARKET WITH A COMMERCIAL PARTNER

Having seen the necessary adaptations for the production and challenges for the commercialisation in general, the Digital Stories on Textile project took a new course with a collaborator, which was interested in selling it through its distribution network. Welspun got to know about the project through a smart textiles researcher who had seen the project in several exhibitions and presentations, and who started to work in the company (CrQ). Textales Little Red Riding Hood edition (2.1.3.3) is developed in collaboration with Unit040, Welspun and Kerstin Zabransky. Welspun India Ltd. (Welspun Group, 2013) is a fully integrated home textile manufacturer. It is one of the largest global home textile producers, with world class manufacturing facilities in India. The Textales Little Red Riding Hood edition was developed as a showcase for their clients. It was shown during the market week they arrange twice a year in New York to demonstrate new products to their clients.

Did the craft and sustainability qualities play any role in this phase, of transferring the project from the research scene to industry? Would the large global home textile producer keep some of the cultural values and meanings from Estonia that are embedded into the smart textile idea, or would they change everything towards efficiency? At the time of writing, it is hard to comment on it, since the first negotiations with clients are ongoing and the end results are not visible yet. For now, it is possible to say that due to the facilities, expertise and market reach of the specific company, the proposal of the product changed from two coloured woven heavy textile into a light satin digitally printed bed linen and digitally printed tufted carpet. The product is still connected to the digital Augmented Reality layer, which carries fairy tales; however more popular ones to be understood by people globally (SrQ). The animations get more elaborated, being more attractive to see. The application (Figure 86) doesn't have several narration forms, as it did in Textales Dream Bear edition (2.1.3.4). It functions in an "open" mode, where the characters

can be found on the canvas in any desired order. The legend can be switched "on", for the story narrated by Zabransky or "off" for viewing the characters performing their actions without the textbox.

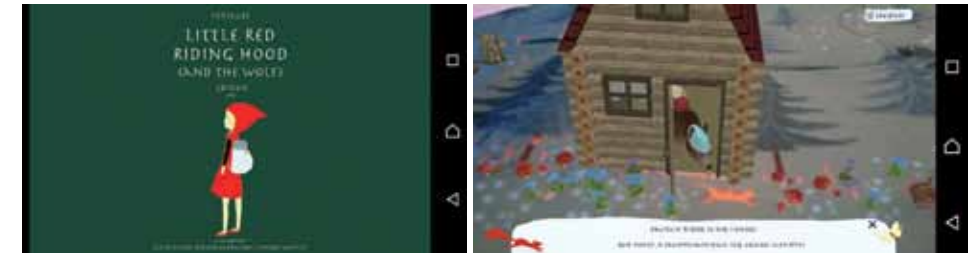


Figure 86 The first screen and the wolf characters captured as a screenshot in the Textales Little Red Riding Hood edition application.

The development of the Textales Little Red Riding Hood edition followed a similar process to the previous Bedtime Stories (2.1.2) and Textales Dream Bear edition development. The development team worked closely together with everybody based in their countries and facilities (CrQ). Zabransky developed the illustrations and the story as a modern version of Little Red Riding Hood (SrQ). In the contemporary version of the fairy tale, the wolf finds the empty house of the grandmother and doesn't eat anybody. The wolf and the Little Red Riding Hood have parallel adventures in the forest on two separate trails leading through the duvet cover. Unit040 gave a 3D life to the characters (Figure 87) as well as connected them to the textile items woven, printed and sewn in Welspun India (MrQ).



Figure 87 Little Red Riding Hood is developed as a 3D character performing several actions on the Textales duvet cover.

The main moments to bring the whole team together were initial ideation, where the scope of the development and future possibilities were agreed, and arrangements to test if everything developed separately came together well (Figure 88).



Figure 88 Testing the carpet and fabric produced in India in the office of Unit040 in the Netherlands.

I cannot reflect on how the craft and sustainability qualities would be treated in a commercial corporation, producing a large portion of the home textiles used in the world at the moment. However, many questions can be posed based on the developed qualities. Would the craft qualities be carried on in the product? How and what kind of meaning would be embedded into mass-produced and targeted products, what kind of message would the material carry as medium? What kind of stories would get hidden into the bed linen? Whose heritage and tradition is carried on through the product? How does it influence the values the parents can communicate through the tales to their children? Will touch and feel of the material remain an essential part in the development of new stories and concepts around the technology? Will the product be produced keeping social responsibility aspects in mind? Does it keep the family connection aspects or would it evolve into an independent game platform? Would the sustainability qualities be carried on in the product? Would an industrially produced product support Minimal Material Consumption, Minimal Use of Energy and Chemicals and Ongoing Development? Would there be an opportunity to set up services for Long Lasting Care that would offer Support for Creation of Meaning, Updates for Personalisation, Platform for Positive Emotions and Empower Relations?

More specifically, once the story gets closer to the traditional version, does it still carry the modern views? If it becomes more generic so as to reach and to be understood by more people, what happens to the personalisation and hidden messages only understood by a specific community? If the animations get more elaborate, being more attractive to see, are they less inviting to interact and touch the fabric? Perhaps these kinds of challenges and questions can be used as an inspiration while developing the commercial version in the future.

The software application used with the bed linen would be offering a service for the users as soon as the product would get to the market (TrQ). Would there also be an option to look into service models for the textile side? Perhaps if the company would apply the principals of sufficiency (Bocken, Bakker, & de Pauw, 2015a), which embody the environmentally most preferable options in the waste hierarchy of avoiding, reducing and reusing, the service aspect for the textile items would also come up. The choice to work with the specific company was because of their great efforts in developing rural areas in India through providing jobs and education. Their social standards are very high, and applied in interesting community projects (CrQ). Welspun has been honoured for green manufacturing and social responsibility excellence in recent years and its effort working with the local community in a small town, Anjar, where the production facilities are located, are remarkable (starting and supporting schools, offering part time work possibilities for women, shelters etc.). The company is also interested in local crafts and values the qualities they carry. I hope we can learn from each other and find challenges to turn into opportunities.

6.2.2.4 REFLECTION ON THE CRAFT AND SUSTAINABILITY QUALITIES WHILE MOVING TOWARDS COMMERCIALISATION

The previous two sections spoke about the crowdfunding campaign and setting up of a production line for the smart textile example Bedtime Stories. Craft and sustainability qualities grouped into material-related qualities (MrQ) and connections-related qualities (CrQ) were mentioned the most. Meaning and stories related qualities (SrQ) were mentioned occasionally and time-related qualities (TrQ) were only mentioned once while describing the

efforts made for commercialisation of the Bedtime Stories.

In the phase towards commercialisation, many decisions and concerns were practical and resources based. Covering production facilities, materials, and techniques the material-related qualities become essential for the phase determining the ways the design would be scaled up. Connections-related qualities got mentioned when deciding on collaboration partners and needed facilities. They also refer to potential users and communities helpful for building content for the digital products. Meaning and stories related qualities came up mainly when talking about the way the proposed concept was communicated and about the initial personal starting point of the Digital Stories on Textile project. Time-related qualities were practically not mentioned since the part of the concept that was attempted to be commercialised was a product, not a service. The main interest to bring the magic storytelling textile to the market has been from the textile industry. The aspects concerning digital development and practicalities in that line have not got attention so far.

In addition, for one of the projects – Vibe-ing – a life cycle assessment (LCA) was conducted to understand better the environmental challenges for smart textiles. The results from the study (van der Velden et al., 2015) gave recommendations above all for material choices for Vibe-ing production. Vibe-ing was chosen for the study because of its complicated composition of textile and electronic components integrated to each other. LCA looked in detail into the materials and techniques used in the smart textile product. It covered the basic use case to evaluate the material impact on the life expectancy of the garments. Combining the LCA study with craft and sustainability qualities can give a more holistic view to the developing product service system. When the material-related craft and sustainability qualities confirm the LCA results for the product design, the rest of the craft and sustainability qualities inspire the service approaches.

It is essential to consider the environmental material impact of products while moving towards commercialisation and mass production. How to ensure that craft and sustainability qualities do not disappear in the step towards industrial machines and piecework? Could the storytelling and other craft qualities, for example be so rooted into Textales product-service concept, that they would get transferred to the end user despite the industrialised processes in between? Or would the industrial production need to adapt some craft characteristics into its workflow in order to enable such transfer? As shown in the previous chapters, the craft qualities became less and less obvious in the project when moving towards manufacturing. Does that mean they became less strong? Perhaps the opposite, as crafty items don't appeal to everybody. People, who like to see obvious craft references in the items they use, typically value the qualities they carry. Therefore, perhaps delivering craft qualities to people not keen on craft looks, would be even more beneficial?

UNEXPLORED POSSIBILITIES FOR TEXTALES 6.2.2.5

Having tried the crowdfunding approach and gaining experience in collaboration with a large corporation, the direct service of leasing Textales products to hosting organisations or households remains unexplored. Not having a dedicated textile-leasing provider in the direct team held us back from looking into that direction. While general households could need some time to adjust to the idea of leasing their home textiles, hospitals and hotels have well-established systems for it. Being able to start with larger volumes would also sustain the production facilities better. Addressing parents at homes or buyers in hosting organisations belongs to the marketing/selling competency that either in a permanent or project-based collaboration model should become part of the team. Applying service design methods to develop

the concept further would mean bringing in relevant partners for implementing suitable service systems. The services should be co-designed with the future service providers. Textales can provide services for storytelling, family connection, learning etc instead of selling bed linen or mobile applications,.

Different cultures could perceive the project differently. Definitely, each part of the world would appreciate different types of stories. But there could be some stories common throughout the world. Perhaps the Textales story could actually connect and bring together different cultures, and help them understand and appreciate each other better? Could it actually be used in a way that one culture could explain its stories to another?

The work has raised several follow-up research questions that could be interesting to explore. For instance, the value of storytelling: would the Textales concept actually encourage fathers to tell their stories to their children? Would the storytelling custom outgrow the Textales duvet cover and Augmented Reality application? Would the storytelling stay even if the duvet would be removed? What kind of stories would be shared via Augmented Reality? Would it help people to talk about taboo and difficult topics? For example, it is used to fight the fear of bugs (Papagiannis, 2012). Could health care staff use the cartoon-like setting to explain medical conditions to children? Would children take the story characters as role models, similarly to movies and cartoons?

Also, the open source scene could be explored further in research. How to meaningfully create digital content for textile based interaction? What level of customisation and DIY would people accept? To what extent would they like to create their personal characters and stories? For example, constructing a whole 3D character differs from altering a pre-made model and even more from attaching small characteristic features onto a pre-made 3D or 2D model. Perhaps in the future, people would have their 3D avatars that can easily be placed into the Textales application. Perhaps they could be created intuitively, molded from a physical material such as clay, or created by pure imagination.

6.2.3 FUTURE OF THE DESIGN PROJECTS

Each project in The Portfolio (Chapter 2) is part of the story of finding and refining craft and sustainability qualities (Chapters 4 and 5). They have been part of the RtD process (Chapter 3) that aimed to contribute to a more sustainable textile field (Chapter 1) through the implementation of technology. Do they stop here? Have they, as means for research, achieved their goal and will rest on the shelves of the university from now on? As the previous versions of each project have transformed into the final versions of Digital Stories on Textile (2.1), Body Sensing and Actuating Networks (2.2) and Thermocraft (2.3), the current section focuses only on the final versions of the projects.

Textales Little Red Riding Hood edition (2.1.3.3) serves as a demo, which shows the possibilities of the Augmented Reality storytelling on textiles. Welspun, together with Unit040, is developing the concept of storytelling on bed linen and carpets further towards a product for the home textile mass market. I am closely involved in guiding the development and seeing where the project is headed. There are other interested parties outside of the home textile area, with whom we will look into the possibilities of developing the concept towards different applications. For instance, to name a few ideas, the magic of Augmented Reality in combination with textiles could be applied to flooring, outdoors games, and theme parks.

The development of Vibe-ing (2.2.3.1) and Well-Be (2.2.3.2) has stopped. The knowledge generated has been published in articles (Bhömer et al., 2013) and shown in exhibitions, where it could be taken further by interested parties. It could benefit, for example, people working on projects for remote patient monitoring programs, such as “Jana: Remote Pregnancy Monitoring” by Heimeier, where she “tackles inefficiencies in the current provision of care to, provide a higher quality of personalised healthcare to pregnant women, living in rural areas, to assist in monitoring preeclampsia, and gestational diabetes through a wearable device” (James Dyson Foundation, 2015).

Butterfly Lace (2.3.3) was a first attempt for a long-distance collaboration between myself, Kooroshnia and Mikkonen. The achieved result has been presented for an academic audience (K. Kuusk, Kooroshnia, & Mikkonen, 2015) and could be further developed for presenting to the design community and to society. The team is eager to continue the collaboration and try to prepare interior elements rather than close-to-the-body applications, due to the current high activation temperatures.

The broad approach of developing smart textiles in three different levels and contexts (home, exhibition, performance) has given a wide platform for further development of smart textiles. Next, it would be beneficial to focus on each direction, and develop the technology as well as the designs with service concepts further. Each combination of textiles and technology in the Portfolio has various sub opportunities that could be explored.

CRAFTS IN THE MODERN WORLD? 6.2.4

Craft practise developed very much in line with nature and seasons. Handicraft was practised in times when it was not possible to work outside in the fields. Even material choices, such as making mittens from softer spring wool and socks from rougher autumn sheep’s wool, resonated with nature and its pace. Powerful ideas emerge when innovation goes hand in hand with nature instead of trying to go against, fight and push its limits. For example, Kayser (2011) uses sun rays for cutting and melting, and sand as raw material to create 3D glass objects in the desert. During his lecture in Designhuis in 2012 he explained how he used the desert itself as a material. As an inspiring example of thinking along with nature, Pauli (2010) explains in his vision about Blue Economy the unforeseen pitfalls of cutting down very important soil fertilisers - mulberry trees, the homes of silkworms – once the textile industry started looking towards oil-based materials. He also points out from learning about silk how the geometries the spiders apply when producing the different types of silk and its medical, chemical properties - there is a potential to turn around the whole production system around. The mulberry tree and silkworms feeding from its leaves provide mulberries, silkworm droppings to soil the earth, silkworm castings that can be developed into silk polymers and by reprocessing that into the geometry of spider silk razor blades, medical products and biocompatible cosmetics can be produced (Pauli, 2010, pp. 98-110).

Similarly, with the exemplified projects, I have aimed to work with nature rather than against it. The concept and final results have emerged naturally from working with the materials in their supportive smart textiles community. They all speak for slowing down textile consumption or life in general in some way. Digital Stories on Textile (2.1) uses the digital dynamic world to moderate the pace between the changes people would like in their life with the one of textiles’ natural life expectancy. The cloth becomes as a representative of an ever-changing imaginary world. Body Sensing and Actuating Networks (2.2) proposes people to be more connected to

their body through activating light or vibration in the knitted garment, offering comfort. The textile becomes a soft interface between the user and the care provider, who can monitor the changes in the user's condition over distance. The concept brings the care provider closer to the user and eliminates the distances needed to be travelled. Thermocraft (2.3) invites users to monitor subtle colour changes on their costume and to focus on the present moment through it. It proposes a communication between the user and the garment itself through temperature changes caused by bodily movement.

Therefore, the smart textile examples created bridge the craft and modern way of living through slowing the pace of textile throughput by giving new meanings to the interactions people can have with textiles. They remind the user how textile material is a powerful medium that is able to communicate digital stories, sense and share information from the body over distance, and change colour according to the way the wearer moves. The projects carry hidden stories – there is always more than you can see. The concepts invite the user to touch and to interact with the material to reveal tactile stories not meant to be discovered purely by looking, but by engaging with the entire body or the hands. The heritage and tradition of the people involved is translated into the smart textile examples. In the case of QR-coded Embroidery (2.1.1) it is made explicit; in the other projects the influences are subtler. Textales (2.1.3) invites the users to take the place of the craftsman and create their own stories, embed their culture and heritage into the stories conveyed to their children. The project supports the family interaction and connection through creative moments shared together. The developed concepts contribute to the social responsibility in various ways. Digital Stories on Textiles emphasises the source of materials and work used in the process of creating the examples. Through that, the social issues in garment production chain are brought to the attention to the user. Body Sensing and Actuating Networks aims to contribute to the social well-being and care for people over distance. Thermocraft hints towards mindfulness and other meditative practises also beneficial for individuals and communities. Textales Sunny Sunday edition (2.1.3.2) explores the possibilities for open source and DIY development of smart textiles. Adapting to modern sharing and learning methods, the technologies used in Digital Stories on Textile and Body Sensing and Actuating Networks have been published in E-textiles swatch book exchange (Hertenberger et al., 2014) for open sharing. The evolution of each of the projects has been described in The Portfolio (Chapter 2). Materials - the cultural and personal as well as the textile and technology related - have changed and improved over the projects iterations. The changing collaboration teams have brought in new aspects each step of the project, and brought insights and results back with them to their area of work. Some of the projects have stopped, some keep developing. The status of each project will be described in next section.

6.2.5 WHAT DID THE RESEARCH BRING TO THE SOCIETY?

This section looks back to the topics introduced in the Introduction (Chapter 1). It reflects on the value of the presented work in the context of culture, clothing, sustainability and smart textiles.

WHAT DOES THE PROJECT MEAN FOR CULTURE & CRAFTSMANSHIP?

The world today is extremely complex. The reality is local and global at the same time every day. Looking back to a local pre-industrial culture setting, where everything was handmade and slow, and mixing it together as a material with high tech ever-changing fast reacting materials and ways of living, has resulted in a portfolio of smart textile explorations and defined craft and sus-

tainability qualities for designing them. It has been an attempt to translate my personal history and cultural heritage through the material of smart textiles into tangible experience to be shared with society. The process has resulted in some harmony, friction and a lot of open questions. The research brings forward a re-appreciation of crafts and craftsmanship. On the one hand, it rejuvenates crafts and craftsmanship through technology. It also grounds technology in the culture by proposing crafts as an initial inspiration and guidance for innovation.

In fact, it has been a constant struggle between harmony and friction through all the developed projects. For example, how to deal with the fact that my personal goal of slowing down textile consumption through the implementation of technology gets opposed to the goals of a large home textile manufacturer, who aims for growth and larger sales of textiles through the innovative attractive technology on textiles? On the other hand, it is also evident that not all the communities in the world need the same kind of approach. While the western world is asked to slow down consumption, the developing world still needs some growth to meet basic needs of all the people in the community. Therefore, there are also different kinds of craft qualities that could support different economic and social systems. The growth and accelerated consumption can also serve the needs of societal responsibility when allowing societies to access basic human needs. However, caution is needed to understand when basic needs become abundance. Issues that look counterintuitive at first sight have been forming and refining my understanding through the process. When something causes difficulties to accept and agree with, it might hide even greater opportunity to broaden the view and understanding.

WHAT DOES THE PROJECT MEAN FOR TEXTILES?

Textiles have carried crafts through industrial revolution to today's technology. They surround and protect people almost every minute of the day. They are very natural to have close and to touch. The way textiles are produced has not changed much from a few hundred years ago. The processes have become automated and therefore it's difficult to grasp each step of the development. What used to be done by the hand of a craftsman is now done by a machine. To get back to the basics of craft techniques such as weaving, crochet, knitting, and lace making broadens the creativity. It gives inspiration to use the very basic constructions of threads in combination with high tech to achieve natural yet modern solutions. For example, using different scales and possibilities, traditional crafting techniques are used in architecture. Gramazio Kohler Research has found drones useful for weaving architectural structures. In architecture, models are usually constructed in 3D, then transformed into 2D and brought to the construction site. With flying objects, this 3D information can actually be used to construct the structures right away (Ben Hobson, 2015). It makes sense in all levels for the process.

Similarly, I've used textile craft techniques as inspiration and a starting point for the smart textile services. Departing from embroidery, weaving, knitting, crochet and lace-making, the projects embed different base structures that reflect in the end results. While woven fabrics and embroidery celebrate touch and durable textiles with stories, so does the Textales (2.1.3) project resulting from them. Knit is especially known for its softness and elastic characteristics. It offers comfort and well-being though a self-care tool Vibe-ing (2.2.3.1). Lace and crochet, both being extremely time and attention demanding techniques, provide luxurious open structures. These qualities show in the developed performance concepts within Thermocraft (2.3). The project aims to communicate that however high tech and automated the production methods and materials become, it might be inspirational and valuable to look back to traditional ways of working from time to time.

WHAT DOES THE PROJECT MEAN FOR FASHION, CLOTHING & SUSTAINABILITY?

Fashion, being an indicator of behavior, highly influences the way people consume and use clothing. Acting clearly outside the fast fashion sphere with the example projects has been a statement towards appreciating clothing that lasts and is meaningful for the wearer for a longer time than the usual fast fashion cycles allow. By the use of technology, I do not aim to create a new fashion, just the opposite. I would like to invite the smart textile designers to reflect on the responsibility they carry for introducing a new area into the turning wheel of consumption. There is a lot of potential in smart textiles to work towards meaningful and long lasting applications instead. I would like to see a society where designs are evaluated by the added value they bring and keep providing for the user over changing times, and not by what sells more and faster. In that spirit, alternative distribution channels for textile items, where users get connected straight to the designers (e.g., Kickstarter), have potential to validate whether the proposed project is needed and ready to be accepted by the envisioned users. Similar platforms also help the designers to shape the ideas towards what the users would actually need.

However my wishes and dreams don't matter much, when they are not being heard further than my immediate community. I need to reach a broader group of users in order to gain voice to speak for the kind of thinking present in the current work outside of the community of people already sustainability conscious and making decisions based on it. Hence the controversial sounding approach of collaborating with a large industrial manufacturer to learn from and with them the potential for sustainability that can be unlocked by the use of technology in textile products. As Pan, Roedl, Blevins and Thomas conclude after a discussion about newness versus Patina, "creating things that are new, enduring and digital is an opportunity space for sustainable design" (Pan et al., 2015, p. 59). The step towards commercially adaptable projects as opposed to conceptual work is made due to the curiosity to find out what happens beyond the one-off pieces. It was also the program provided by CRISP and supported by a diversity of industry partners involved in the Smart Textile Services project.

Taking a step further, and imagining a world where the Augmented Reality functionality would be unobtrusively integrated into our daily lives, a lot of the excess in the material textile and fashion world could be avoided. For example, simple plain black and white clothing could be seen through the Augmented Reality feature in full colors, visual textures, and patterns. For example as the Zeitguised studio's *geist.xyz* (Bruney, 2016) project proposes to imagine clothes on our backs that could become digital canvases. What would happen if we could choose how to see the world? Would we end up living in a self-created bubble, or would we build a better world for everybody? What if there is another reality in our clothes, home textiles, floors, wallpapers, streets, etc.? It would definitely be interesting for branding, however, what could it mean for customisation and life within those textile spaces?

WHAT DOES THE PROJECT MEAN FOR TECHNOLOGY?

When the visionary cinematographer Heilig (1962) filed the patent application for the Sensorama machine, he covered aspects from both Augmented as well as Virtual Reality. He had built an immersive multi-sensory device that allowed the users to experience emitted aromas, environmental elements such as wind, vibration, and sound while watching a movie screen in an enclosed space. Augmented Reality then moved to the headset (Janin, Mizell, & Caudell, 1993) for manufacturing accuracy, and into the pocket-sized smartphones, for entertainment in 2000s. The 3D graphics used for the software have improved considerably over time, allowing

very fluent and detailed motions to be played in tablet and smartphone devices. The Augmented Reality experience can be envisioned to move to smart glasses or lenses in the near future, but above that the market leaders predict main developments in the field of image, object, and color recognition. They see few niche markets, such as snowboarding, psychotherapy, and museums that have already seen beneficial Augmented Reality applications. They see more developments away from single-viewer experience towards collaborative interactive experiences that would help the technology to move mainstream. (Sawers, 2011) Merel (2015) points out the main benefit of Augmented Reality compared to Virtual Reality being the freedom to move around while using the application. While Virtual Reality places the user into a virtual location (which is safer to enjoy by not moving around in the physical space), Augmented Reality brings the virtual elements into user's physical space. He predicts the markets of Augmented and Virtual Realities to grow similarly to mobile phones. "We forecast that AR/VR could hit \$150 billion revenue by 2020, with AR taking the lion's share around \$120 billion and VR at \$30 billion" (Merel, 2015). It gives certain confidence that the technology will reach people and become much more accessible. By the time of developing the Textales applications, there was no wide known combination of textiles and Augmented Reality applications. In fashion, the examples have mainly appeared in retail for promoting, showing wider selections and trying on products, bringing catwalk experiences to the shops, etc. There are some initiatives printing images and connecting them through a QR-code to t-shirts (Harmony Internet Ltd, 2012). A collaboration project between fashion designer Marga Weimans and AugmentNL (2013) was shown during the Amsterdam Fashion week – a more sculptural approach to projecting Augmented Reality content on garments: Hyperfabric. However, I have not seen any Augmented Reality textile interaction examples out there besides Textales. Virtual Reality has gained more popularity in fashion brands for showcasing the collections and marketing purposes (Fumo, 2015). The project shows an alternative use for Augmented Reality, perhaps the meaningful one the field is looking for? Digital interaction through textile touch built on craft and sustainability qualities could be one of the developing directions for Augmented Reality market.

This dissertation focused on achieving more sustainable textile items through the implementation of technology. Digital stories on Textile claimed to increase the sustainability of textile items through adding digital stories that could change in time, to the traditional fabric. However, could it work the other way around? Would people keep the smartphones longer if the digital story that is attached to their textile is compatible with their old gadget? High quality textiles outlive the gadgets by several lifetimes. Would people be motivated to keep the gadgets as long as the textile is in use?

WHAT DOES THE PROJECT MEAN FOR SMART TEXTILE SERVICES?

As described in the Introduction (Chapter 1), smart textiles and wearable technology date back to 1880, with several development phases and ways of integrating textiles and technology. Also the craft approach has been taken before (Kettley, 2008) in designing wearable technology. Sustainability of smart textiles has been investigated from the environmental point of view (Köhler, 2013) and further developed by the example of the current project (van der Velden et al., 2015). What this research offers is RtD approach for developing smart textile examples in three different levels of integration and periodical evaluation cycles to develop craft and sustainability qualities by means of expert reviews. It shares a first person perspective for designing with cultural, personal, textile and technology as materials.

The newness of the smart textile services is definitely an opportunity for sustainability. While a typical user does not pay attention to the care labels of the purchased textile item, the smart

textile piece immediately catches their attention. They wonder how it's proper to wash it, how to care for it. This gives an opportunity, a window for the smart textile designers to provide clear care instructions that direct the user towards more sustainable use of the textile items. However, it poses a challenge, if the newness is adapted by conventional fashion cycles and carried into the fast fashion cycles. This project encouraged smart textile services to take a sustainable standpoint. It proposed services as the intangible products having great potential to carry craft and sustainability qualities. "In 1930, the average American woman owned nine outfits. Today, that figure is 30 outfits — one for every day of the month" (Johnson, 2015). People possess excess of things, and therefore those are stored in houses, and tossed into trash six months after the purchase, on average (Leonard, 2007). Services, and specifically smart textile services could disrupt that cycle.

I like to see smart textiles opposing the conventional fashion cycle a little bit because of the different expertise needed in the development of such projects. This research suggested interrelations between old crafts and new technologies. Crafting smart textile services was proposed as a meaningful direction for achieving environmental, societal and economic sustainability. If fashion-driven garment production works as a game, every rule fine-tuned and followed by the people playing it – on the producer as well as consumer side – the smart textile field functions more as a story. It is still a fantasy with an opportunity to become a part of positive rituals of life.

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APPENDICES

APPENDIX 1: PRESENTATIONS

Date	Project	Presentation	Event	Location	Town	Country	Layer
15.11.2015	YB-ML	YB-ML performance	YB-ML performance	Pecsi Harmadik Színház	Pecs	Hungary	Society
13.11.2015	YB-ML	YB-ML performance	YB-ML performance	Tomcsa Sándor Theatre	Székelyudvarhely	Romania	Society
22.10.2015	Textales	Craft qualities in smart textile services	DRIVE: Smart meets circular	Natlab	Eindhoven	Netherlands	Society
07.06.2015	YB-ML	YB-ML performance	YB-ML performance	M STUDIO	Sfantu Gheorghe	Romania	Society
15.05.2015	YB-ML	YB-ML performance	YB-ML performance	Figura Studio Theatre	Cluj-Napoca	Transsylvania	Society
19.03.2015	All projects	Crafted smart textile services	Prague Fashion Weekend: FashionTech	Qayra	Prague	Czech Republic	Society
19.02.2015	All projects	Crafted smart textile services	Tech Sisters	Pipedrive	Tallinn	Estonia	Society
20.12.2014	YB-ML	YB-ML performance	YB-ML performance	Dock 11	Berlin	Germany	Society
26.11.2014	QR-coded Embroidery, Bedtime stories, Textales	Crafting qualities in designing QR-coded Embroidery and Bedtime Stories	The Art of Research 2014 conference	The Art of Research 2014 conference	Helsinki	Finland	Community
15.10.2014	YB-ML	YB-ML performance	YB-ML performance	Bakelit Studio Theatre	Budapest	Hungary	Society
14.10.2014	YB-ML	YB-ML performance	YB-ML performance	ALTERRA Old Synagogue	Szeged	Hungary	Society
13.10.2014	Well-be, Textales Dream Bear	Design dialogues: Shapng (un)common grounds	Archintex	TU/e	Eindhoven	Netherlands	Community
24.09.2014	YB-ML	YB-ML performance	YB-ML performance	Barnes Crossing	Cologne	Germany	Society
09.09.2014	All projects	Smart textile products and services in sustainability context	Ambience conference	Tampere Hall	Tampere	Finland	Community
27.03.2014	Bedtime Stories	Bedtime Stories	Nerds on stage	Rotterdamse Schouwburg	Rotterdam	Netherlands	Society
04.03.2014	QR-coded Embroidery, Bedtime Stories	Smart textiles	Stuk op Tafel	Torpedo Theater	Amsterdam	Netherlands	Society

22.10.2013	Bedtime Stories, Vibe-ing	Baltan Open Lab: Wearable senses	Dutch Design Week	Natlab	Eindhoven	Netherlands	Society
10.09.2013	All projects	Designing sustainable smart textile services by taking the craftsmanship approach	Researchers' breakfast	Aalto Media Factory	Helsinki	Finland	Community
29.06.2013	CHACUN(E)	CHACUN(E) performed by Angelina Deck	Chisenhale Dance Space	Chisenhale Dance Space	London	UK	Society
09.06.2013	CHACUN(E)	CHACUN(E) performed by Angelina Deck	All there is – Iets op Bach	Korzo	The Hague	Netherlands	Society
06.06.2013	Vibe-ing	Vibe-ing	Smart Textiles Salon	Museum of Industrial Archaeology and Textiles	Ghent	Belgium	Community
11.04.2013	QR-coded Embroidery, Bedtime Stories	Bedtime Stories	This Happened	WORM	Rotterdam	Netherlands	Society
19.04.2013	CRISP STS	Smart textile services crafted curtain	Design review Session	Lijm and Cultuur	Delft	Netherlands	Community
28.01.2012	QR-coded Embroidery	Hypercrafting Fashion	Hypercrafting fashion	Waag Society	Amsterdam	Netherlands	Society

APPENDIX 2: EXHIBITIONS

From	To	Project	Exhibitor	Location	Town	Country	Layer
27.11.2015	17.04.2016	Well-be	Please touch!	Museum of Design	Zürich	Switzerland	Society
17.10.2015	25.10.2015	Textales LRRH	DDW: Mind the Step	Klokgebouw	Eindhoven	Netherlands	Society
17.09.2015	20.09.2015	STS	Design Night Festival: Smart textiles - wearable services	Suka EKA	Tallinn	Estonia	Society
07.09.2015	11.09.2015	Butterfly Lace	ISWC 2015	Grant Front Osaka Knowledge Theatre	Osaka	Japan	Community
03.09.2015	03.09.2016	Tender	Interlaced	Boiler House	London	UK	Society
23.07.2015	15.08.2015	Vibe-ing	Smart Flexibility: Advanced Materials and Technologies	Design Research Institute	Melbourne	Australia	Society
04.06.2015	04.06.2016	Well-be	Dutch Technology Week: Tech Meets Design: Innovation Exchange	Conference Center The Strip	Eindhoven	Netherlands	Society

23.05.2015	25.05.2015	STS	Openluchthotel 2015: Smart textiles - wearable services	De Burcht van Leiden	Leiden	Netherlands	Society
01.03.2015	31.10.2015	Smart Phocus	Beit Ha-ir Museum	Beit Ha-ir Museum	Tel Aviv	Israel	Society
21.01.2015	22.02.2015	STS	Smart textiles - wearable services	Textile Museum Tilburg	Tilburg	Netherlands	Society
14.01.2015	17.01.2015	All	Heimtextil: Smart textile services samples	Messe Frankfurt	Frankfurt	Germany	Society
18.11.2014	20.02.2015	Butterfly Lace	Archintex: Shaping (un)common grounds	Tio3	Ronse	Belgium	Society
18.10.2014	26.10.2014	Textales Dream Bear, Textales Sunny Sunday, Vibe-ing	DDW: Mind the Step	Klokgebouw	Eindhoven	Netherlands	Society
13.10.2014	17.10.2014	Well-be, Textales Dream Bear edition	Archintex: Shaping (un)common grounds	TU/e	Eindhoven	Netherlands	Comm
01.10.2014	01.01.2015	Bedtime Stories, Thermocraft	Smart Textiles	Texperience center	Goirle	Netherlands	Society
01.10.2014	31.12.2014	Smart Phocus	TU/Delft	TU Delft	Delft	Netherlands	Society
20.09.2014	20.09.2015	Bedtime Stories	The night of art & science	Museum de Lakenhal	Leiden	Netherlands	Society
13.09.2014	17.09.2014	Bedtime Stories, Tender	E-textiles 2013 Swatchbook	ISWC 2014	Seattle	USA	Society
25.06.2014	16.11.2014	Vibe-ing, Bedtime Stories	Smart Flexibility: Advanced Materials and Technologies	Design HUB Barcelona	Barcelona	Spain	Society
10.06.2014	10.06.2015	Bedtime Stories, Tender	E-textiles 2013 Swatchbook	MAK, the museum for applied art	Vienna	Austria	Society
07.04.2014	27.04.2014	Bedtime Stories, Vibe-ing	Archintex: Shaping (un)common grounds	Auckland University of Technology	Auckland	New Zealand	Society
27.03.2014	27.03.2015	Bedtime Stories	Nerds on Stage	Rotterdamse Schouwburg	Rotterdam	Netherlands	Society
23.03.2014	28.09.2014	Bedtime Stories, Vibe-ing, Thermocraft	Tradition meets future	De Kantfabriek	Horst	Netherlands	Society
28.02.2014	12.04.2014	CHACUN(E)	Saskatchewan Wearable Art Exhibition	Saskatchewan Craft Council gallery	Saskatoon	Canada	Society
28.01.2014	15.03.2014	Bedtime Stories, Vibe-ing	Co-created wearables	Baltan Laboratories	Eindhoven	Netherlands	Society
22.01.2014	31.01.2014	Bedtime Stories, Vibe-ing	Archintex exhibition	Vilnius Academy of Art	Vilnius	Lithuania	Society

06.01.2014	08.01.2014	Bedtime Stories, Vibe-ing	Archintex exhibition	Art Academy of Latvia	Riga	Latvia	Society
01.11.2013	31.12.2013	Smart Phocus	Openbare Bibliotheek	Openbare Bibliotheek	Amsterdam	Netherlands	Society
26.10.2013	26.10.2013	CHACUN(E)	Wearable Art Gala	Vaughn Wyant Automotive Group - Mercedes Showroom	Saskatoon	Canada	Society
26.10.2013	28.10.2013	Bedtime Stories	Evolution	Evoluon	Eindhoven	Netherlands	Society
19.10.2013	27.10.2013	Bedtime Stories, Vibe-ing	Design changes	DDW: Design United	Eindhoven	Netherlands	Society
14.10.2013	18.10.2013	Bedtime Stories, Vibe-ing	Archintex exhibition	Tio3	Ronse	Belgium	Society
05.10.2013	06.10.2013	Bedtime Stories	InFashion Festival	Hotel Dom	Utrecht	Netherlands	Society
26.09.2013	03.10.2013	Vibe-ing	The Dutch Pavilion	Beijing Design Week	Beijing	China	Society
23.09.2013	03.10.2013	Bedtime Stories	Sustainable and innovative fashion seminar	Aalto University School of Arts, Design and Architecture	Helsinki	Finland	Society
22.09.2013	25.09.2013	Vibe-ing	DesForM	Wuxi Museum of Chinese Calligraphy and Paintings	Wuxi	China	Society
20.09.2013	24.12.2013	Vibe-ing	Designing Health	Designhuis	Eindhoven	Netherlands	Society
02.07.2013	05.07.2013	Vibe-ing	Design 4 Health conference	Sheffield Hallam University	Sheffield	UK	Society
09.06.2013	12.06.2013	Bedtime Stories	NORDES 2013 Exhibition	School of Design	Copenhagen	Denmark	Communit
06.06.2013	06.06.2014	Vibe-ing, Bedtime Stories	Smart Textiles Salon	Museum of Industrial Archaeology and Textiles	Ghent	Belgium	Society
26.03.2013	29.05.2013	Smart Phocus	Te[ch]x(t)iles	MOTI Museum of Image	Breda	Netherlands	Society
28.10.2012	16.12.2012	Tender	Pretty Smart Textiles	Tio3	Ronse	Belgium	Society
20.10.2012	28.10.2012	Tender, Bedtime Stories	Wearable Senses exhibition	DDW: Videolab	Eindhoven	Netherlands	Society
06.10.2012	06.10.2012	Tender	Night of the Nerds	NEMO science center	Amsterdam	Netherlands	Society
18.05.2012	18.05.2013	QR-coded Embroidery	Crafting Future	DEAF	Rotterdam	Netherlands	Society
20.04.2012	22.04.2012	Crisp curtain	Smart Textile Services	Milan Design Week: Design Academy Eindhoven	Milan	Italy	Society
03.12.2011	15.01.2012	QR-coded Embroidery	Smart Textiles	Tio3	Ronse	Belgium	Society

SUMMARY

CRAFTING SUSTAINABLE SMART TEXTILE SERVICES

The world is looking for solutions to major sustainability challenges that developed with the consumer culture. Among other fields and aspects, the way people design, produce, wear and dispose clothes in the traditional cradle-to-grave model has gained interest. The garment life cycle is continuously innovated from different angles. Examples of sustainable materials, business models and ways of thinking about clothing appear in research and practice both. Independently, the fashion scene gets more and more curious about the possibilities of using electronics and digital properties in clothing, also known as fashion technology, wearable technology and smart textiles. The marriage of the two worlds, that closely influences many people, carries potential concerns and opportunities. Textile manufacturing was one of the drivers of the development of technology from pre-industrial craftsmanship to today's industrialized consumer culture. In this work, crafts and craftsmanship are taken as an example of sustainable living. The traditional crafts and sustainability are discussed in the context of the developing field of smart textile services. This doctoral dissertation examines the following central research question: what are craft and sustainability qualities and how are they implicitly used in the design of smart textile services?

This dissertation builds upon the pre industrial crafts and craftsmanship attitude as an example of sustainable living. Chapter 1 introduces the background and the motivation to look into crafts, and how they fit into the context of sustainability. Textiles move from culturally meaningful items prepared with the craftsmanship approach to industrially mass produced clothing sold in a fashion system. The chapter covers approaches to sustainability in the journey towards more sustainable fashion design. Among others, services are touched upon as a promising direction for sustainable clothing systems. Chapter 1 introduces smart textiles with their development from wearable light bulbs in the 1880s to the recent work in research, arts and industry. It gives a brief overview how a set of smart textile examples is developed and reviewed with the help of craft and sustainability experts from the respective angles.

The smart textile services portfolio is presented as a context for developing the craft and sustainability qualities. Chapter 2 introduces three project lines, each with a different level of integration of textiles and technology: separated, integrated and combined. Digital Stories on Textile explores the interaction possibilities arising from the combination of static textile and digital information in different form(at)s, e.g., image, video, text, audio, 3D objects, animated 3D objects. Some of the possibilities are illustrated in three sub-projects: QR-coded Embroidery, Bedtime Stories and Textales. Body Sensing and Actuating Networks explores the interaction possibilities in the combination of soft textile materials and techniques, such as felting and knitting, and electronic components, such as LED-s and vibration motors. Some of the possible directions are illustrated in three sub-projects: Felt Ball, Tender, Vibration Therapy. Thermocraft explores the traditional property of textile to fade or change color in time by the use of thermosensitive yarns. Some of the related ideas are illustrated in a performance costume with thermosensitive yarns

CHACUN(E), a choreography partly inspired by thermosensitive conductive yarns YB-ML and a sensing-actuating thermosensitive multicolor lace Butterfly Lace.

The process of designing with craft-inspired smart textiles has followed the Research through Design approach. Chapter 3 gives an overview of the approach and introduces the background of the designer researcher as the translator between the material and the world. The RtD process involves interaction between the material, as the designer researcher's cultural background mixed with smart textiles and crafts, and the designer researcher. Both influence each other and result in tangible representatives – prototypes of the intangible values built through personal history. The community around the designer researcher, consisting of designers and researchers participating in closed events and conferences, continuously challenges and nurtures the projects as well as the research outcomes. The results are presented to the broader society, outside of the immediate community, through exhibitions and public presentations. Chapter 3 introduces the relationship between the material, the designer researcher, the community and society in the development of the craft and sustainability qualities, seen in the context of smart textile services.

Traditional crafts carry a tacit meaning embedded into the items and the process of making and using them. Chapter 4 introduces the craft qualities in folk garments through the example of the Muhu skirt in Estonia. It develops by comparing the folk skirt to the smart textile examples QR-coded Embroidery and Bedtime Stories. The comparison is made by means of qualitative interviews with selected craft experts. The first round of interviews results in the first version of craft qualities: Embedded meaning, Material as a medium, Hidden stories, Heritage and tradition, Touch and feel, Societal responsibility, Family connection, Open source community, Evolution in time. The craft qualities are applied in two re-designs of Bedtime Stories: Textales Dream Bear and Textales Sunny Sunday editions, where the craft experts evaluate them. The second version of the craft qualities deepens and becomes more concrete based on the designer researcher's reflections on the experts' comments.

Challenges for the environmental, societal and economic sustainability in textile and garment production and use are described in Chapter 5. Services and smart textiles are proposed as a potential direction for the sustainable fashion. Within the scope of the study, the selected sustainability experts share their opinions about the sustainability qualities in the separated, integrated and combined smart textile examples Bedtime Stories, Vibe-ing and Thermocraft. The first round of interviews results in the first version of sustainability qualities: Minimal material consumption, Minimal use of energy and chemicals, Ongoing development, Long lasting care, Support for creation of meaning, Updates for personalization, Platform for positive emotions, Empower relations. The sustainability qualities are applied in two redesigns of Bedtime Stories: Textales Dream Bear and Textales Sunny Sunday editions, where the sustainability experts evaluate them. The second version of the sustainability qualities deepens and becomes more concrete based on the designer researcher's reflections on the experts' comments.

Finally, Chapter 6 summarizes the main findings and implications of the studies described in previous chapters of this dissertation. It offers a reflection on the craft and sustainability qualities towards the future. The craft and sustainability qualities are presented as material, meaning, time and connections related qualities with their main insights, implications and possible future uses. The impact of the work is discussed in the context of applying the craft and sustainability qualities in commercial projects. As such, this chapter integrates the previous chapters, and serves to answer the central research question in this dissertation. Finally, this chapter describes the future of the design projects, crafts in the modern world through other works and gives an overview of what did the work bring to the society.

PUBLICATIONS RELATED TO THIS RESEARCH

JOURNAL ARTICLES

Kuusk, K., Wensveen, S., & Tomico, O. (accepted). Craft Qualities evolving from traditional crafts to smart textile services. *Studies in Material Thinking*, 16.

van der Velden, N. M., Kuusk, K., & Köhler, A. R. (2015). Life cycle assessment and eco-design of smart textiles: The importance of material selection demonstrated through e-textile product redesign. *Materials & Design*, 84(C), 313–324.

Kuusk, K., Tomico, O., Langereis, G., & Wensveen, S. (2012). Crafting Smart Textiles – a meaningful way towards societal sustainability in the fashion field? *The Nordic Textile Journal*, 1(6-15), 6–15.

BOOK CHAPTER

Kuusk, K. (2013). Crafting Meaningful Smart-Textiles. In *Social Fabric* (pp. 27–31). Eindhoven: SOCIAL FABRIC.

PROCEEDINGS & CONFERENCE CONTRIBUTIONS

Kuusk, K., Kooroshnia, M., & Mikkonen, J. (2015). Crafting Butterfly Lace – Conductive Multi-Color Sensor-Actuator Structure. Presented at the International Symposium on Wearable Computers, Osaka.

Kuusk, K., Wensveen, S., & Tomico, O. (2014). Crafting Qualities in Designing QR-coded Embroidery and Bedtime Stories (pp. 1–12). Presented at the Art of Research V, Helsinki.

Kuusk, K., Niinimäki, K., Wensveen, S., & Tomico, O. (2014). Smart textile products and services in sustainability context (pp. 1–8). Presented at the Ambience 14&10i3m, Tampere.

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Bhömer, M., Jeon, E., & Kuusk, K. (2013). Vibe-ing: Designing a smart textile care tool for the treatment of osteoporosis (pp. 192–195). Presented at the Design and Semantics of Form and Movement, Wuxi.

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GENERAL INTEREST PUBLICATIONS

Tomico, O., Wensveen, S., Kuusk, K., Bhömer, M., Ahn, C., Toeters, M. J., & Versteeg, M. F. (2014). Day in the lab: wearable senses, Department of Industrial Design, TU Eindhoven. *Interactions*, 21 (4), 16–19.

Kuusk, K., Toeters, M., Baggerman, M., Wirtz, P., Koppejan, I., & Tomico, O. (2013). Making opportunities tangible. *Crisp*, (1), 20–23.

CURRICULUM VITAE

- 1983** **K**risti Kuusk was born on November 4th, 1983 in Pärnu, Estonia. Since 1991, when her parents started a garment production company, she has spent parts of her summer holidays helping out at Pambu Ltd. She studied Information Technology at the Tallinn University of Technology, specializing in information systems analysis, and graduated with a BSc degree in 2005. She worked for four years as a project manager analyst at Vita Group Ltd, while at the same time pursuing creative studies. She acquired an MA degree in Fashion Design at the Estonian Academy of Arts in 2011. During her studies, Kristi worked three months as a design intern in the garment production company Goodwill Impex Ltd in Jaipur, India, where she saw and felt the other side of the glamorous fashion business. She spent one year as an exchange student in the University of São Paulo, Brazil, where she started to experiment with the combination of textile and technology. An internship at the Interactive Institute Stockholm, Sweden directed her from visual communication in garments to the tactile properties that technology carries. The group collection “Live well” earned her course the winning award in the Industrial Pret-A-Porter category at Habitus Baltija in Riga, Latvia in 2010. A continuation project from the MA collection “LED scarf” earned her a Shourei-shou - Incentive award, the fifth prize in the international 6th Snow Design competition in Ishikawa, Japan in 2011.
- 2011** In the summer of 2011, Kristi started a PhD project at the Eindhoven University of Technology, which resulted in this thesis on craft and sustainability qualities in smart textile services. The related collaborative design work was presented in various international exhibitions, shows and conferences.
- 2014** In 2014 Kristi founded the company Spell disain Ltd, bridging traditions and innovation, textiles and technology. In the context of the company, she is working on follow-up projects, applying the knowledge gained from her PhD research.



