

Crafting Stories: Smart and Electronic Textile Craftsmanship for Interactive Books

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ABSTRACT

‘Crafting Stories’ investigates the potentials of smart and electronic textile craftsmanship in the context of interactive books. A handmade interactive eTextile book, copying a handmade interactive textile book my late grandmother made, is presented as a prototypical artefact. The presentation of this practice-based research at the intersection of textile crafts, electronic and computational technology, and storytelling explicitly focuses on the interactive qualities, materials used, and the story experience. It introduces and contextualizes ‘The Book My Grandmother Might Have Made’, annotates design decisions, and pictures the making of the book. I report on early explorations of users interacting with the crafted stories and close with discussing the possibilities and perspectives of crafting tangible, embedded, and embodied interactions within (eTextile) books.

Authors Keywords

Textile; Crafts; Craftsmanship; eTextiles; Interactive Stories; Books; Tangibles; Children; Storytelling

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CSS Concepts

- Human-centered computing~Interaction design

INTRODUCTION

Books propose an exciting platform to investigate form, function, and qualities in the context of ubiquitous, smart, electronic, and computational technologies. The affordances of physical books in combination with digital possibilities have long been probed to interact with virtual and augmented reality applications, to serve as learning support systems, or as play artefacts (for children), as well as within artistic and experimental installations [e.g.5,7,9,12]. In these examples, books were used as interfaces to projections or other effects external to the book. Aesthetic and material-oriented research explored interactivity through electronically enhanced pop-up elements [e.g.19,25] as well as directly within the pages of the book [11]. They focused on books as an interactive medium, inherent material qualities (paper), and the crafting process bringing it into being.

The work presented here builds on these projects. It is related in material to [14], a three-page interactive fabric ‘touch and feel book’ integrating sound and LEDs, and tested with children [10]. Electronically augmented books are also commercially available [e.g.21,22], usually featuring areas activating sounds when touched. However, examples so far often put limited emphasis on an intuitive integration of the materials and interactions and the effects produced within the story experience.

THE BOOK MY GRANDMOTHER MIGHT HAVE MADE

This pictorial presents a twelve pages long interactive electronic textile (eTextile) children book: *The Book My Grandmother Might Have Made*. It is part of an ongoing practice-based research process that aims at exploring the relationships between craftsmanship, smart and electronic textiles, aesthetics, interaction, learning, and play. The work was inspired by a textile book my late grandmother actually made in early 1980s and gave to me when I was around 18 months old. She had used her skills as a seamstress and craftsperson to fabricate an interactive textile book. The embedding of snaps, buttons, zips, and various other textile accessories allowed for attaching, opening, moving, rearranging, among others, bringing individual stories to life.

Decades later, I revisited this book from my perspective as a researcher and artist working at the intersection of traditional crafts and computational technologies. I made a book inspired in form, motives, techniques, aesthetics, and interactive stories by what she had crafted. In addition, I incorporated computational technologies and smart and electronic textiles [3] to augment textile interactions she proposed with new visual effects, movements, and sounds that can be activated either by the user(s), their play partner(s) or their surrounding. Through this work, I intend to explore how a craft approach to interactive technologies can support tangible interactions and multi-sensory experiences of interactive and tactile books.

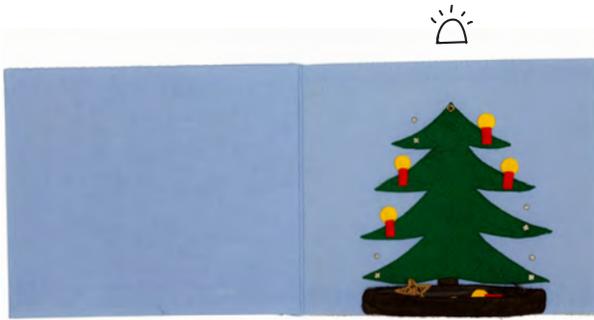
12 INTERACTIVE
SMART & ELECTRONIC
TEXTILE PAGES

STORIES SPANNING THE
COURSE OF THE YEAR

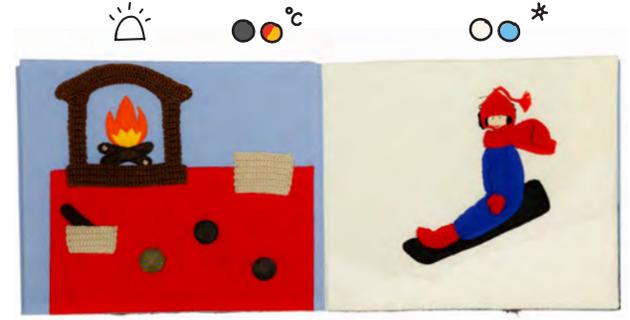
34 x 27 x 10 cm



FRONT COVER

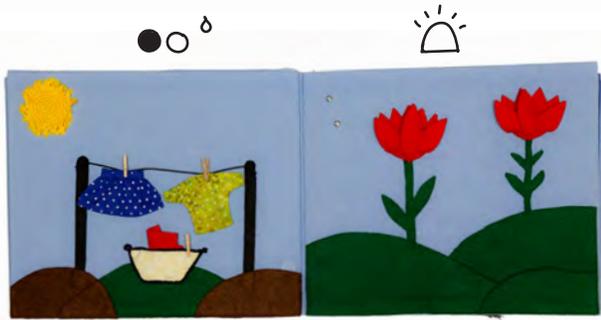


HOLIDAY TREE



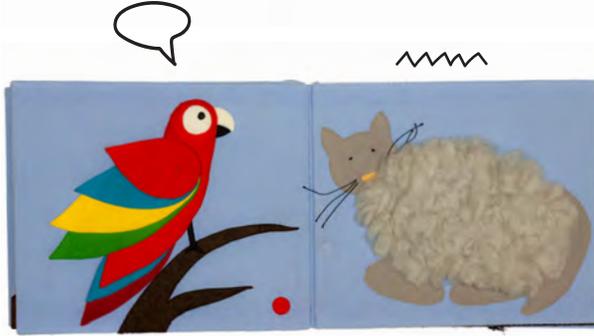
LIVING ROOM

WINTER



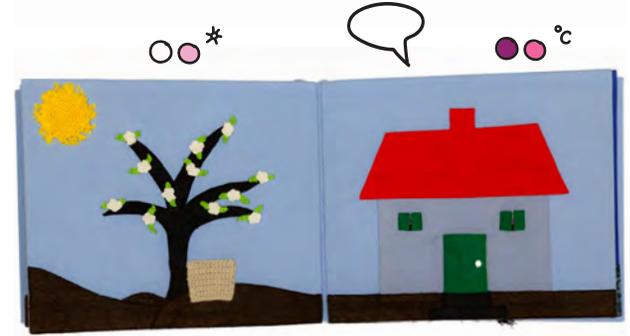
WASHING LINE

FLOWERS



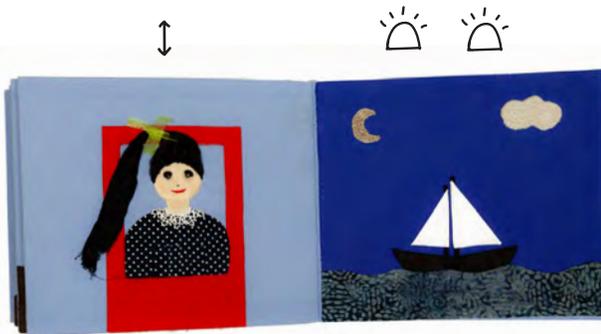
PARROT

CAT



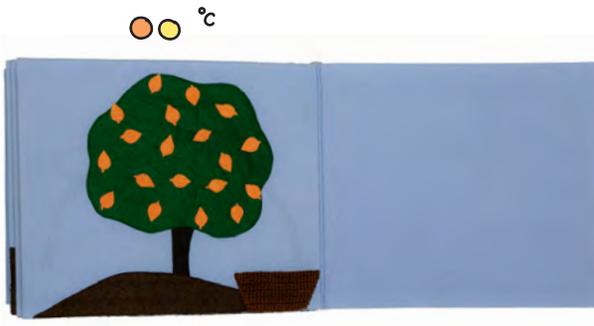
SPRING TREE

HOUSE

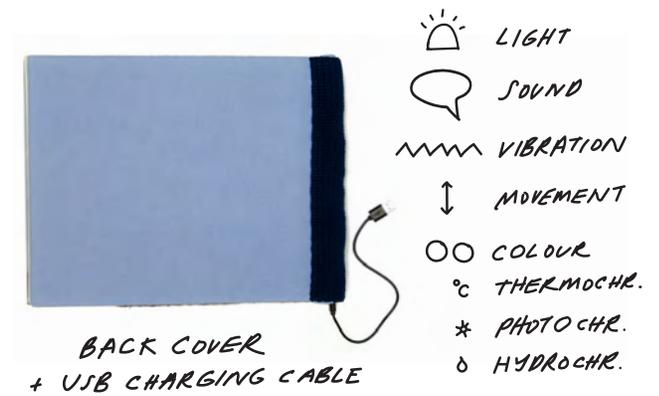


GIRL

SEA



FALL TREE



BACK COVER
+ USB CHARGING CABLE

-  LIGHT
-  SOUND
-  VIBRATION
-  MOVEMENT
-  COLOUR
-  THERMOCHR.
-  PHOTO CHR.
-  HYDROCHR.

MOTIVATION

The work was motivated by very fond memories playing with the book as a child, as well as my current practice in the field of eTextiles. The latter drove my curiosity to explore the role of emerging technologies for playful everyday artefacts; the former contributed memories of fulfilling analogue interactive experiences. Admiration for my grandmother's ideas and craft skills embedded in the original book additionally motivated me to deeply engage with the work.

The deliberate choice to replicate the pages had two reasons: to understand and honour the work put into the making of the original book and to achieve relative comparability between the original and the new book for future evaluation settings. I targeted a similar age range as my grandmother: I started playing with the book as a toddler and played with it well into kindergarten, probably even longer, according to my parents. ① The interactive elements of the book addressed and offered diverse forms of engagement, being accessible to small children as well as providing activities to grow into: Fine motor skills, "small muscle movements requiring close eye-hand coordination" [20] of 18 months olds allow for pincer grasps to pick up and hold an item [8]. Subsequent development is closely associated with cognitive and adaptive development, with infants knowing both what they want and how they can accomplish it [8].

I approached the making of the eTextile book engaging with material and process through craft's sensibility and sensitivities - continually challenging the artefact being made, relying on empathy and intuition to create objects



① ME AS A CHILD PLAYING WITH THE BOOK MY GRANDMOTHER MADE

and experiences of lasting value [23], ideally again for future generations. Beyond crafting the artefact well, specific motivation lay in crafting the story well: to fabricate aesthetic experiences that are creative, enlivening, and expressive and involve the senses in inclusive and fulfilling activity [24].

Specific emphasis was put on the 'beauty' of the textile-electronic integrations and the interactive experience: Material interactions and electronic effects should relate to each other [2] and provide children with a 'suitable', transparent scenario [10], as well as potentially open up a new layer of the story. My guiding motivation was to imagine the book my grandmother might have made, would she have had access to and knowledge of eTextiles. I understand the resulting process as practice-based research, undertaken to gain new knowledge through the making of the book as well as the outcome of that process [4].

APPROACH

I started the process by taking photos of each page and sketching how to integrate smart elements into the storytelling: material, aesthetic, and electronic qualities should interplay with the story, together they would provide hints at possible interactions, and be a playground for free explorations. ② Electronic and computational elements should deepen, support, or intensify the play and storytelling. However, they must never impose themselves upon the user, distract from other details, or merely prompt the activation of an effect without the interaction leading to this activation being aesthetically and contextually embedded. Disembodied (repetitive)



② PHOTOS OF THE ORIGINAL (GRAY) AND SKETCHES FOR NEW E-TEXTILE PAGES

automatic triggering of an effect must especially be avoided, as preventing free play, and thus other possible stories from being imagined. Added effects should naturally integrate with physical interaction.

Page 1 is an example where the physical interaction is the same as in the original book but augmented with electronics: the original version had a tree, and candles and a golden star attachable via snaps. The new version also displays a tree, candles are equally attachable via snaps, but additionally light up when the star, made out of golden metal thread, is placed on top - functioning as a switch closing the circuit. Another example are the pages 8 and 9 showing a blossoming tree and a house ③: In the original book the blossoms, again attached via snaps, could be collected, and the window and door of the house opened. A figurine was standing in the doorway, and flowers were behind the windows. In the new version the blossoms, crochet and dyed with photochromic pigments, turn purple when in sunlight. When the door is opened, the figurine greets with a message previously recorded. The flowers in the window, screen printed with thermochromic pigments, change their colour when touched. While the interaction is the same as in the original book, the blossoms reacting to sunlight allow to include environmental conditions into the narration. The recording could, for example, let two people asynchronous play with each other, leaving each other voice messages through the figurine.

In the following, individual pages, interactive elements, and side-by-side comparisons between the original book and the eTextile iteration are pictured and annotated.

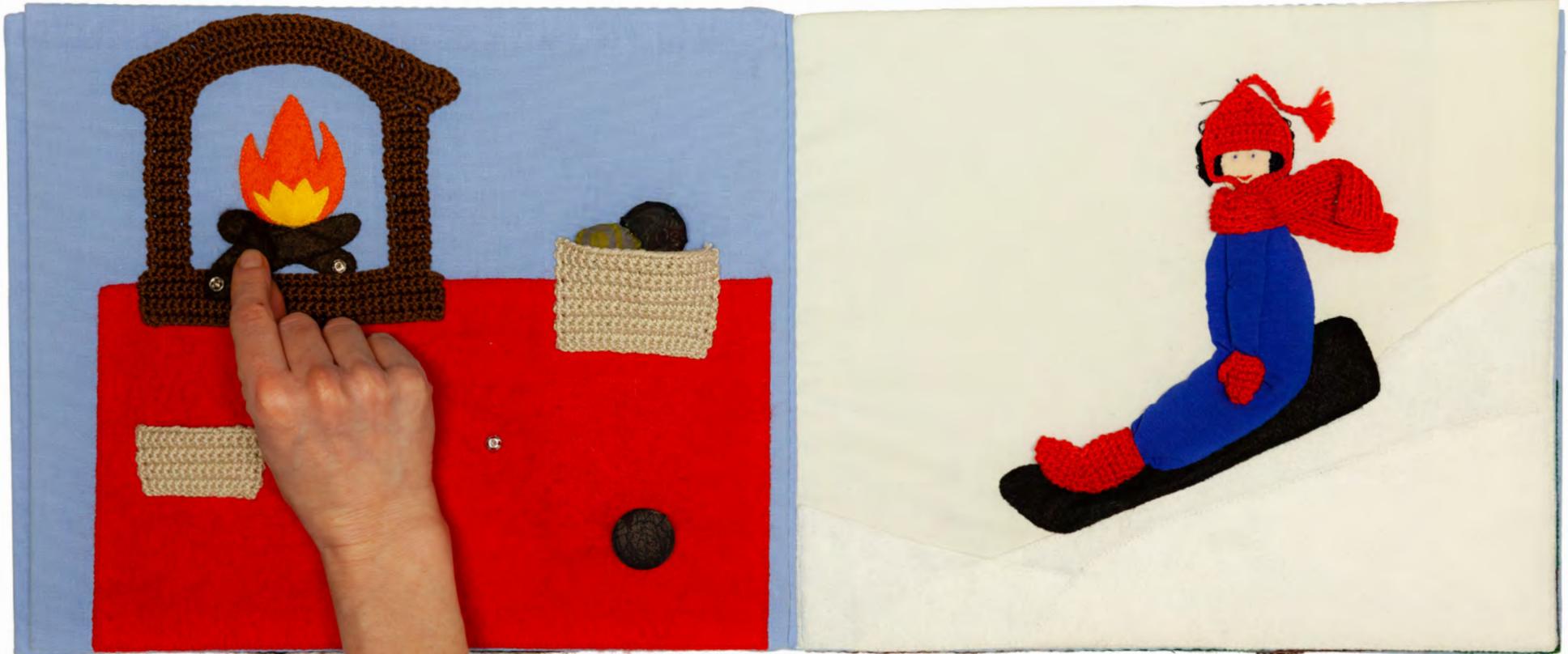


③ SKETCHING INTERACTIONS FOR A PAGE

MOVABLE ELEMENTS



AMBIENT INTERACTION WITH SUNLIGHT



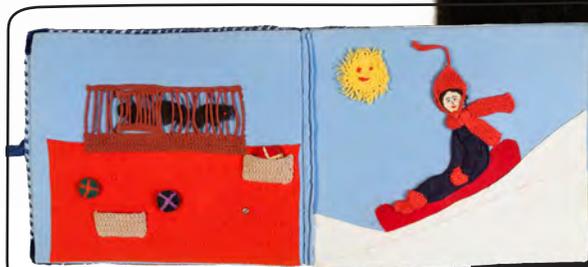
Page 2 - Living Room

Page 3 - Winter

PUT WOOD ON THE FIRE TO LIGHT IT UP

TOUCH THE BALLS TO CHANGE THE COLOUR

IN SUNLIGHT THE SKY TURNS BLUE



ORIGINAL BOOK



LOG = SWITCH



THERMO CHROMIC PAINT



SKY: PHOTOCHROMIC PRINT



Page 6 - Parrot

Page 7 - Cat

WHEN OPENING THE PAGE THE PARROT WILL REPEAT WHAT HAS BEEN RECORDED

WHEN THE CAT IS CARESSED IT PURRS



ORIGINAL BOOK



RECORD MESSAGE

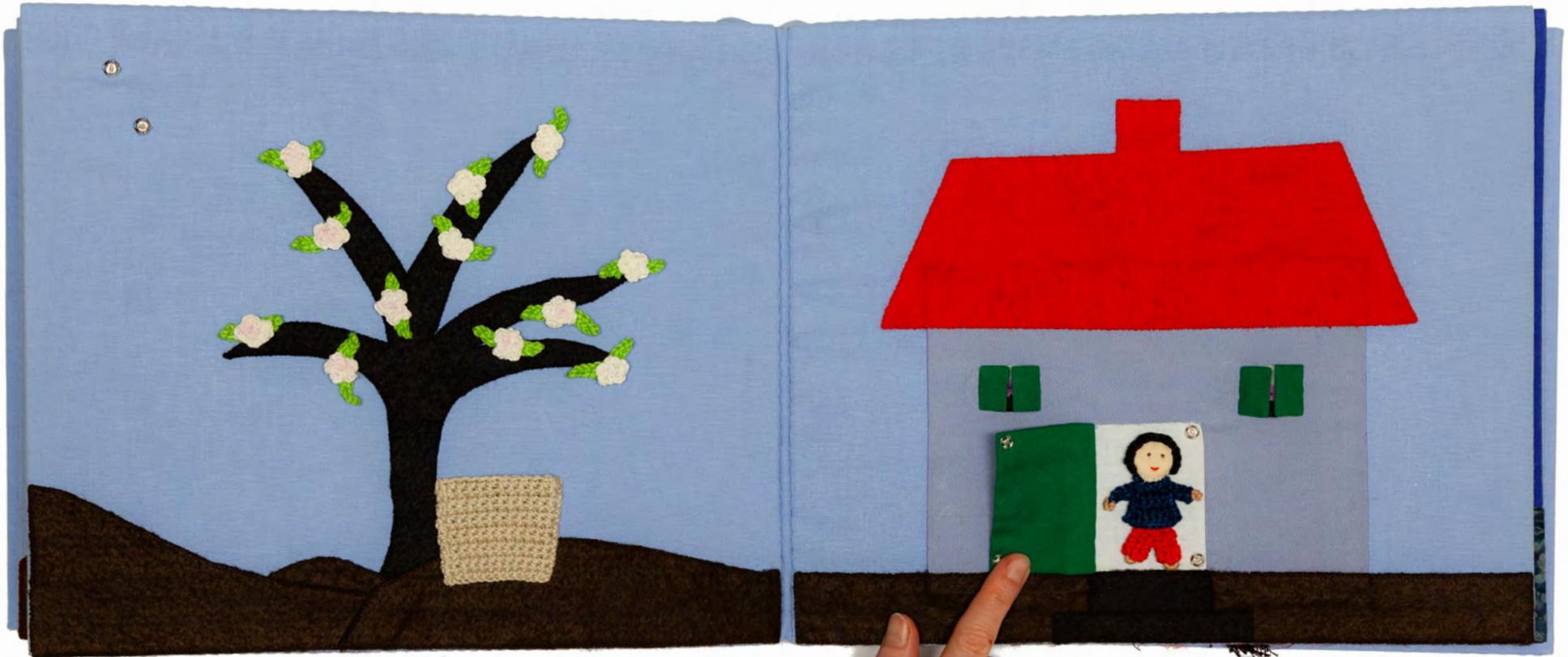
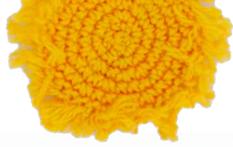


MOVEABLE FEATHERS



WOOL + STAINLESS STEEL SENSOR

AMBIENT INTERACTION
WITH SUNLIGHT



Page 8 - Spring Tree

Page 9 - House

IN SUNLIGHT
BLOSSOMS TURN PURPLE

THE PERSON GREETS WITH A
MESSAGE PREVIOUSLY RECORDED



ORIGINAL BOOK



FLOWERS: PHOTO-
CHROMIC PAINT



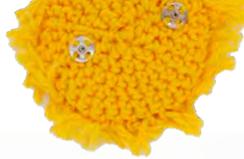
FIGURINE COMPLETES CIRCUIT



FLOWERS: THERMOCHROMIC PAINT



©Photo: Karja Grojlat



PLACING SUN, MOON & CLOUD
ACTIVATES DIFFERENT EFFECTS



Page 10 - Girl

THE GIRL'S HAIRSTYLE
CAN BE CHANGED

EVERY FEW
SECONDS THE
GIRL BLINKS

UNDER
MOONLIGHT
YOU CAN SEE
THE STARS

Page 11 - Sea

SUN AND RAIN
PRODUCE A
RAINBOW

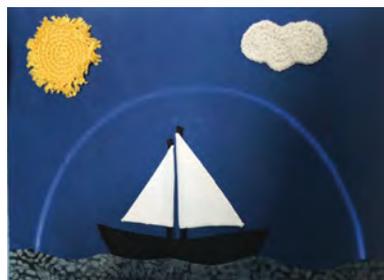
IN A CLOUDY
NIGHT THERE
ARE NO STARS



ORIGINAL BOOK



MAGNETIC BEAD / COPPER COIL

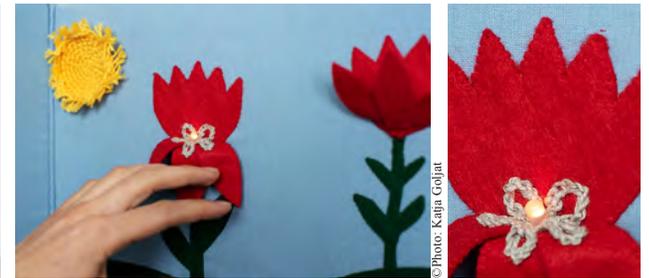
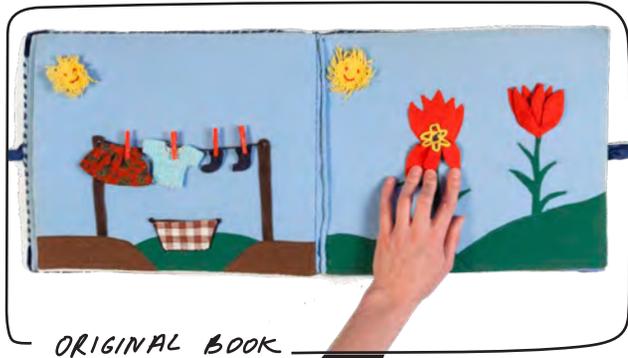
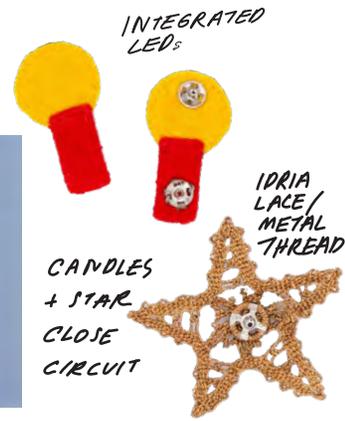


RAINBOW: OPTICAL FIBER



MOVEABLE STARS

©Photos: Kaitia Grogan



FALL LEAVES CHANGE COLOUR WITH TEMPERATURE



MAKING OF

I pondered the idea of an eTextile book for a few years before I started the work during a stay as an artist in residence in Ljubljana, Slovenia, a few hours' drive south of where my grandmother grew up. There, I reached out to local craftspeople to contribute their skills in screen printing and a specific local lace technique. After the residency, I had assistance from a textile crafts student.

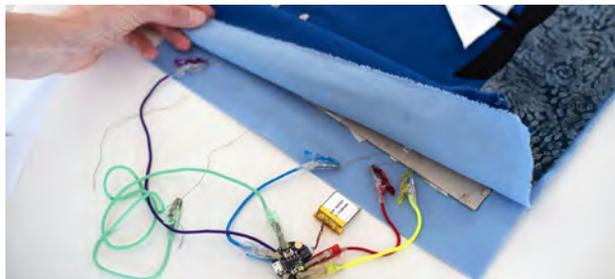
The base for all pages is a light blue cotton fabric stretched over cardboard. I used felt in various colours and mixed patterned fabrics for sewn applications. Many moveable elements are crochet. The cat's hair is a rya knot weave. The star and the girl's collar are Idria Lace, produced after the example from the original book, the star being made from golden, conductive thread. Smart textile elements include fabrics and threads, screen-printed or painted with thermochromic, hydrochromic and photochromic pigments, resulting in colour changes with rising temperature (e.g. leaves turning from orange to yellow), water contact (e.g. laundry showing a different pattern when dry) or exposure to UV-light (e.g. sky turning blue when the sun shines).

eTextile elements include textile sensors [15] and actuators [17], as well as textile cables [16] as communication lines and for power transmission. I used copper threads for almost all conductive connections. I used silverized copper threads to crochet the moon, and gilded copper threads to make the lace star. In both cases, the material was chosen for visual appearance purposes as well as for its conductive properties to form a switch. I used metal snaps both to attach elements and as conductors, and plastic snaps to realise two distinct points of contact on a snap (e.g. figurine on page 9). For the textile sensors, e.g. for pressure and stretch sensors, I used a spun wool and silver blend (e.g. flower and cloud, see on previous pages), and unspun wool and stainless-steel blend (e.g. cat hair). Here again, both, the aesthetic and the electronic qualities of the material were taken into consideration. No standard hardware sensing components were used.

I used enamelled copper wire wound into a coil as an electromagnetic actuator on page 10. I sewed a magnetic bead in its centre, painted as a pupil. When the coil is under power, the dot turns, resulting in the eye blinking

when activated. Other actuators include LEDs, speakers, and vibration motors. I integrated them into the motive where possible (e.g. the integration of LEDs as visual elements of the flowers or the integration of the speaker into the person's head). If a direct integration was not possible for aesthetic or functional reasons, LEDs were mounted on the cardboard to shine through the fabric (e.g. stars in the sky). The cardboard between the pages was individually cut and engraved with a laser cutter to fit connections. The cardboard also holds a reed contact for all electrically active pages. Activated by a magnet on the opposite page, the reed contact only closes and activates the circuit of the respective open pages.

Digital input and output processing happen on an Arduino nano board, a motor shield, and two greeting cards modules. All processing units are mounted on cardboard at the back of the book and connect to the individual pages with textile cables and snaps to allow flexibility and repair. The microphone to record messages for page 9 is also mounted at the back. The book is powered with a lipo battery and has an integrated charger. A switch at the back turns the electronics off.



©Photo: Katja Goljat

④ INNER CARDBOARD + TESTING CIRCUIT



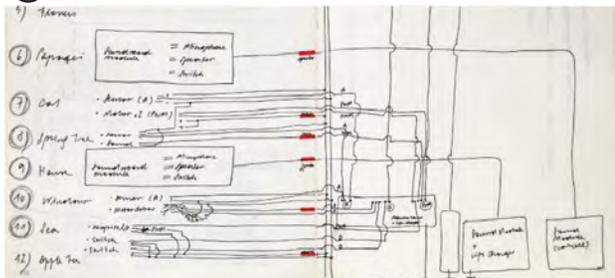
©Photo: Katja Goljat

⑤ RYA-KNOT: WOOL/STAINLESS STEEL BLEND



©Photo: Katja Goljat

⑥ PHOTOCROMIC PAGE IN THE SUN / ORIGINAL



⑦ SKETCHING THE WIRING OF INPUT / OUTPUT



©Photo: Katja Goljat

⑧ ELECTRONICS AT THE BACK OF THE BOOK



⑨ USB-PLUG AND ON/OFF BUTTON

INTERACTING WITH THE BOOK

So far, only limited settings allowed observing interaction with the book. I invited children to engage with it for an extended time period and observed visitors at an exhibition the book was displayed at. Preliminary data about these experiences can briefly and anecdotally be reported here.

As part of the first test with children, a four-year-old girl and an eight-year-old boy were invited to play with the book. No further instructions were given. They were not present at the same time, so they each played on their own. The younger girl, initially a bit shy, soon started to explore what she could move, open, rearrange and activate. The candles lighting up made her smile, apparently encouraging her to explore the stories on the next pages further. She did figure out all intended interaction possibilities on her own, ⁽¹⁰⁾ but she gave them differing attention. She spent the most time on the page with the cat - first examining the purring with her hand, later repeatedly coming back to that page and also exploring it with her full body, laying her head on the book to hear and feel the purring. ⁽¹¹⁾ As she got more familiar with the book, she also started mixing the elements from different pages - putting the flower from page 8 onto the tree on page 12. ⁽¹²⁾ The girl played well over 15 minutes with the book until her father called her.

The boy, on the other hand, was very reluctant at the beginning. He seemed not interested to explore the book but was eventually prompted to do so by his mother. He tried all the pages ⁽¹³⁾ and flipped several times through the whole book without paying much attention. Then,

the parrot talking as he opened the page caught his attention, and made him stop and smile. ⁽¹⁴⁾ He started interacting with it, recording and re-recording messages and letting the parrot repeat it time and again as he opened the page.

These insights from children interacting with the book were complemented by a mixed group of adults and children interacting with the book in an exhibition setting. Among this older audience, while they also seemed to enjoy exploring the book, many questions centred around how specific effects were achieved. This setting also provided first insights into how the book can be interacted with by more than one person at once: people did engage on two opposite pages, shared the experience of a single page, ⁽¹⁵⁾ or discussed with each other what they could do next and then collaborated to do so.

Seeing these shared experiences developing, both through simultaneous play, as well as through previously recorded messages, was especially interesting. In the comparably brief time of this preliminary user testing, it was hard to explore the effects influenced by ambient conditions. For example, as it was a cloudy day, there was not enough sun to see a blue sky (page 3), or the blossoms blooming/ changing colour (page 8). Revisiting the book across several days in diverse conditions would allow exploring more triggers for different stories. It will be especially interesting though to observe the children interacting with the book over an extended time period, see how stories develop over time, and potentially also comparing the play evolving from the old book and the new book.

CRAFTING STORIES

Development of the book described here probably started around the same time, and independent of [14]. However, many of the suggestions resulting from their study of infants playing with the three-page long prototype have been implicitly addressed in *The Book My Grandmother Might Have Made*. Honauer et al. described the importance of shared experiences; of interactive touch-and-feel books needing to allow for both interacting alone or with another person. They also described the importance of the choice of characters and storylines. In the example presented here, these decisions were, for the most part, taken by my grandmother. She needs to be given credit for developing both, stories that are brief and short in interaction - which is essential for young children - as well as the possibility of narration to play out across several pages for older ones [10].

I understand the formulation of storyline and character in the eTextile book to be confirmed by the considerable time spent with the book, especially by the younger girl. Time spent with the book can be seen as standing in relation to the number of pages. However, the page number, beyond a quantitative increase, might also qualitatively contribute to the experience of an overall story, as it allows to deepen the immersion into the universe proposed.

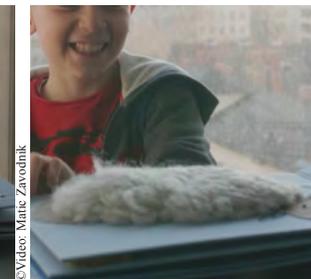
As stated in the beginning, it was a precondition for me the electronic elements are well integrated, supporting the overall experience, and by no means become an 'annoying' effect - to craft stories that mimic and subtly enhance interactions children are familiar with [10].



⁽¹⁰⁻¹³⁾ PLAY-TESTING WITH A 4-YEAR OLD GIRL



⁽¹³⁻¹⁴⁾ 8-YEAR OLD BOY INTERACTING



⁽¹⁵⁾ CO-INTERACTION

I credit the slow and reflective, empathetic and intuitive craft process [23] as well as experience in the eTextile field with being able to balance that. This is distinctly different from the books commercially available that mostly propagate the pressing of a button to activate a sound, no matter the experience that might provoke that sound.

The process of manually crafting each interaction forced the interaction concept to pass several lengthy stages: first, a design phase to collect initial ideas for interactions; second, to research adequate materials to fulfil desired functions and integrate well into a textile book; ⑩ third, deciding and preparing the individual pages; fourth, crafting the individual pages, increasingly integrating visual and interactive elements. ⑪ To craft the particular interactive features, to exercise judgement and care as they emerge [18], resulting in a slow and incremental process critical to the formulation of the actual interactions on a visual, haptic, and activity level. Inherent to the textile material, unstitching, unravelling and disconnecting is often possible without a loss in material or quality, allowing for a fifth iteration when the page was already thought to be finished.

Working with smart and electronic textiles allowed to extend craft qualities also towards the computational and electronic interactions; eTextiles make a seamless integration of form and function on a material level possible, thereby enabling diverse tangible interactions. The textile materiality and the familiar format of the book possibly contributed to intimate, and at times, embodied experiences.

Starting from an existing interactive textile book to investigate the development of an interactive eTextile book was a very distinct approach. It was also a very long and personal one, through the artefact making carrying on memories from the past to potentially become memories for future generations [1]. The approach, the concept and the limitations proposed by the original proved to be valuable constraints to check and balance the euphoria of adding computational technologies; to “elevate digital artifacts out of the realm of functional ‘gadget’ into the realm of object with personal significance and uniqueness” [24]. Through the iterative and reflective crafting, I often ended choosing the least intrusive eTextile augmentation. Already these subtle nuances though showed the potential to shift attention in the interaction.

CONCLUSION AND FUTURE WORK

To me, *The Book My Grandmother Might Have Made* was a starting point into exploring potentials of eTextile in the context of interactive books. It has been a personal journey, as well as one towards deepening insights into the role eTextile craftsmanship can play among today’s interactive technologies, especially in the context of children’s play and interactive objects. ⑫

In the context of a tactile book, technology was not expected, or attractive to the users per se, but had to couple with materiality and storytelling in order to contribute and potentially positively alter individual multi-sensory experiences. The experience and early insights from the making of this book may translate to the subtle augmentation of material interactions across

a broad spectrum of applications, among them play, and potentially, learning artefacts, as well as artefacts of daily use.

I understand this work to be the first of an ongoing research project. Future work aims to look at 1) how proposed interactions and artefact play out in a real-life setting: What qualities can new technological developments bring to this form of storytelling? What forms of interactions and engagement can evolve, or are prevented? 2) transfer insights into books for other audiences than children, e.g., connecting it with specific experiences and stories that might be especially suitable to be told in textile. 3) explore the transfer of these forms of crafted interactions to other disciplines concerned with storytelling, as well as to connect to their approach through a shared interest. 4) reflect on aspects of sustainability and longevity in the context of electronic crafts.

ACKNOWLEDGMENTS

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⑩ PREPARING MATERIALS



⑪ CRAFTING INTERACTIONS



⑫ THE FINISHED ETEXTILE BOOK

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