9 Opportunities of Interactive Textile-Based Design for Education Tools for Children with Various Spectrums of Alertness Sensitivities

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Introduction: Textile Design and Social Design

Whilst social design can improve human livelihood and well-being, it offers designers challenges to tackle with traditional materials and approaches. For nearly ten years, social design projects at the Estonian Academy of Arts have touched upon the applications of textile knowledge and skills for the creation of teaching and therapeutic tools for children and adults with special needs. By collaborating with various care and support organizations in Tallinn, the projects capitalize on the traditional textile design students' skill base, and at the same time encourage the student cohort each year to learn additional electronic textile properties, so that they can apply these consolidated skills and knowledge of textiles and electronics in a social context.

This chapter will take a recently completed social design project as an example to demonstrate the way in which traditional textile skills can be combined with electronic textile properties to solve specific problems designated by social care services. In spring 2017, the final-year textile design bachelor students received an assignment to design tools and playful interactive textile-based educational games for the Tallinn Children Hospital's Mental Health Center's multisensory room. As pointed out by Salonen (2008), an interactive multisensory sound room is a learning environment. It adopted ideas from Montessori pedagogy where the pupils actively explore different ways of using selected sensory materials. Learning occurs by playing or experimenting with immediate feedback. In this way, the pupils gain internal motivation to explore and learn new things (Hayes & Höynälänmaa, 1985). The interactive multisensory environment provides direct and indirect stimulations of sensory modalities. For people with autism, for instance, the following stimulations are advised: visual stimulation (sight), auditory stimulation (sound), olfactory (smell), gustatory (taste), tactile stimulation (touch), and proprioceptive and vestibular stimulation (movement) (Collier, n.d.).

Electronic textiles, also known as e-textiles, smart textiles, or intelligent textiles, are generally different combinations of textiles and electronic materials and techniques. They have been used in products or solutions for health improvements. For example, Philips' *PLACE-it* project proposes BlueTouch as light therapy for pain relief and Bilirubin blanket for neonatal jaundice phototherapy care (van Os & Cherenack, 2013). Another example is a series of e-textile weaving workshops with blind and visually-impaired people conducted by Emilie Giles and Janet van der Linden (2015); they find that "eTextile pieces, simply put together by people using their own hands and imagination, can form a powerful way to tap into people's creativity and raise their curiosity" (p. 10). Giles and van der Linden (2014) have also explored the possibilities of touch-based interaction in connection with the materiality of e-textiles. Co-creation of textiles by people with impairments can be seen in a project led by Sense, a national charity, in which people with sensory impairments over the age of 50 in Islington, London, work together for twelve weeks at Islington Museum to design a patchwork representing their memories (McEwan, 2015). In the educational context, Lara Grant at California College of the Arts works with her students on designing a wearable device or soft interface for people with cerebral palsy (Grant, 2016).

In the project to be exemplified in this chapter, the students were encouraged to use electronic textiles together with their traditional textile design background in their work. However, they were also allowed to develop textile-based interactive tools with no relation to electronics. The students began by participating in a one and a half-week introductory workshop on soft switches where they learned the basics of soft electronics, electronic circuits, and programming Arduino. After the workshop they started with the social design project in which they were required to design and prototype interactive textile-based educational tools.

Process of Designing Interactive Learning and Therapy Tools

At the start of the project, Tallinn Children's Hospital special needs educator introduced the needs of various spectrums of children's alertness sensitivities to the students. The students were asked to develop learning and therapy tools for the specialists to use in their daily work with their clients. The students could choose to work either individually or in self-formed pairs. In the cohort reported here, one student worked individually and four other students worked in pairs, creating three interactive tools that will be introduced in the next section of this chapter.

The participating students all had background in textile design and wished to develop their knowledge of social design and e-textiles. First, the basics of social design and educational development of children were introduced to the cohort. They learned about the sensory room concept (International Snoezelen Association, 2017) and visited a multisensory room in a local children's hospital in Tallinn. A special needs educator from the hospital talked to the students, describing a typical working day, patients, tools, and procedures. The students could try some of the existing tools equipped in the multisensory environment. They were introduced to the Lovaas approach, which is a behavioral treatment model typically used with children with autism aged between two and eight (Lovaas Institute, 2005). In this approach, social interaction and cooperative play are integral; parents and instructors interact with a child through one-to-one activities in order to establish rapport and develop constructive and positive relationships.

As a next step, the students were asked to envision a new tool for the special needs educator. The design had to fit into the existing multisensory room, benefit the clients, and suit the hospital's requirements (such as easy to clean, reliable, etc.). Along with sketching and ideation, the students were encouraged to start rough prototyping, e.g., building the tool from available materials in a quick way. These materialized ideas were reviewed by the special needs educator, who then provided feedback based on her experience. After that, the prototypes were improved, refined, and built from more reliable and refined materials.

Three Prototypes of Interactive Learning and Therapy Tools: *UUDU*, *SHPACO*, and *TEKK*

UUDU: TOOL FOR COLOR/PATTERN MATCHING AND TEXTURE EXERCISES

The first student project *UUDU* (Figure 9.1) has a soft rotatable hexagonal wheel divided into color and pattern sectors and attached to a wooden panel painted in the same colors and patterns on the top part. The title *UUDU* came from the word "puudutama" which means touch in Estonian. It draws inspiration from a tactile color wheel game for blind children that introduces colors using tactile objects, braille, and social play (Bobnar, n.d.), and interchangeable textured

Figure 9.1. *UUDU* by Helen Grass and Irina Pommer, 2017. It has a soft rotatable wheel for matching exercises and changeable material swatches for tactile exercises. Photograph: Helen Grass, Irina Pommer. © Helen Grass, Irina Pommer, and Estonian Academy of Arts.

rollers (Technical Solutions Australia, 2015) with five different textures that provide sensory awareness. The rollers encourage reaching, swiping, and grasping.

UUDU enables children with various spectrums of alertness sensitivities to play color or pattern-matching between the painted plywood box and the soft cushion wheel according to the task given by the educator. The bottom part of the prototype that aims at encouraging children's free exploration of different textures contains three soft rollers around which changeable textured bands can be attached using Velcro. The bands are made of various materials, such as beads, sequins, yarn, felt, and fabric, with a variety of techniques including printing, crochet, beading, embroidery, and appliqué. The interchangeable materials invite the child to touch and spin the rollers. Children can replace and organize the covering bands on the backside of the prototype (Figure 9.2). These bands can be placed on the rollers to match descriptive pictures or words (e.g., soft, coarse, etc.). *UUDU* is equipped with 15 textile bands whose material properties can be compared to words. Additional pictures, graphics, or words can be attached on to pillow with Velcro.

The proposed design encourages children to explore different textures and colors. Having multiple uses and levels of difficulty, the design gives the flexibility to choose tasks with different levels of difficulty suitable for children with various abilities. Some elements of *UUDU* can be used in different ways, therefore not all the use-cases have been envisioned and can be further developed by the child and his/her teacher. The interchangeable, washable covers also allow the tool to be cleaned as required by the hospital's requirements and staff.

The team had several advanced material concepts, which they neglected in the process. For example, they were thinking of filling the rollers with water that would create different sounds when rolled as well as change its state when frozen. They also played with the idea of using portable microphones to emphasize the sound of materials through speakers. They wanted to add LED lights that would turn on in a certain color when the respective color buttons were pressed.

These concepts were explored through rough prototyping but were not developed because they did not correspond to the requirements of the hospital environment and children needs.

SHPACO: INTERACTIVE GAME FOR LEARNING COLORS, SHAPES, AND PATTERNS

The second student project *SHPACO* [SH = shapes; PA = patterns; CO = Colors] (Figure 9.3) aims to help children with various spectrums of alertness sensitivities to recognize colors, shapes, and patterns, and to balance the body. The floor game with soft switches invites two participants to play. Each symbol represents one color, one shape, and one pattern. Each color, shape, and pattern appears twice on the textile surface. For the exercise, the instructor can stand on one color and ask the client to find the same color, or do the same with shapes or patterns (Figure 9.4).

SHPACO draws inspiration from Moto tiles (Entertainment Robotics, n.d.), an interactive floor tiling for the elderly to practice balancing the body, and from shape memory games that help people to train memory function.

Figure 9.2. *UUDU* has material exploration swatches that can be attached to the rollers as well as backside of the prototype with Velcro. Photograph: Helen Grass, Irina Pommer. © Helen Grass, Irina Pommer, and Estonian Academy of Arts.

Figure 9.3. *SHPACO* by Maria Teng, 2017. It is an interactive floor game that allows children to learn colors, shapes, and patterns. Photograph: Maria Teng. © Maria Teng and Estonian Academy of Arts.

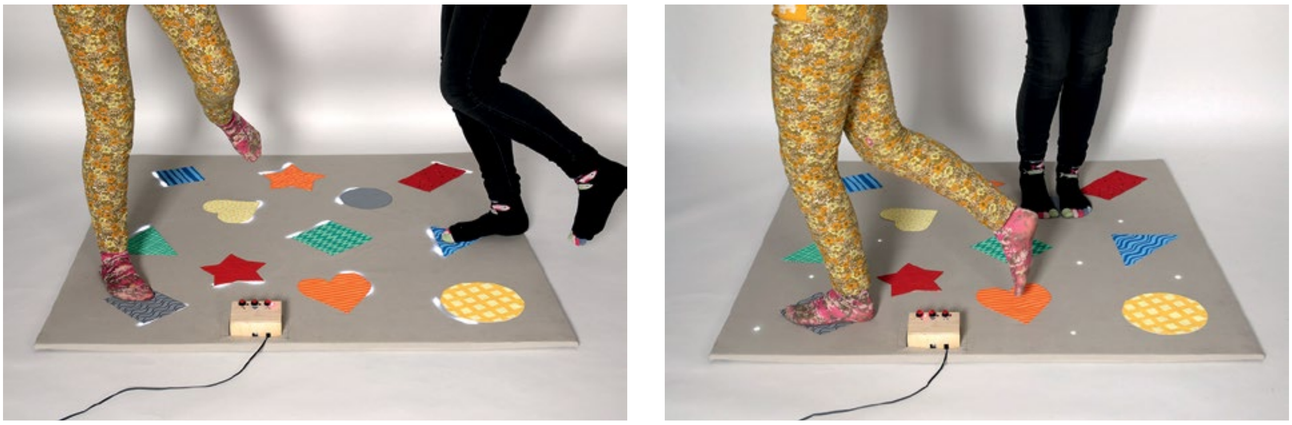

Figure 9.4. *SHPACO* invites the collaborative players to recognize different colors, shapes, and patterns. Photograph: Maria Teng. © Maria Teng and Estonian Academy of Arts.

Figure 9.5. Overview of how the *SHPACO* project was made from design concept, silk-screen printing, color mixing to embedding LED-s into tubes, creating channels for the connection wires, and programming its behavior. Photograph: Paul Urbel. © Maria Teng, Paul Urbel, and Estonian Academy of Arts.

SHPACO uses bright colors and large shapes in combination with sometimes more-difficult-to-distinguish patterns. The variety of exercises and levels of difficulty make the game usable for a large group of people of different spectrums of alertness sensitivities and ages. The colorful patterned shapes are made of silk-screen water-soluble pigment printing on cotton fabric (Figure 9.5). For easy cleaning purposes, the whole fabric cover is removable from the recycled-felt base, which is embedded with electronic components, such as LEDs, resistors, transistors, electrical wire, conductive fabric, and conductive yarn. The game is controlled by the switches on the plywood box with an Arduino Uno hidden inside and connected to the electronics embedded in the base and a power cord.

SHPACO builds upon this student's previous work, a small flower with color-matching petals, created during the introductory workshop on soft switches. She scaled it up into a play mat and changed the programming code based on the newly developed interaction and item layout. She tested what needed to change when replacing a small smart textile item with a large soft electronic prototype. She managed to solve several technical challenges along the way, such as the use of soft and hard electronics combined, running wire within the textile surface, and protecting electronics from being stepped on.

TEKK: MULTIFUNCTIONAL THERAPEUTIC BLANKET

The third student project *TEKK* (Figure 9.6) is a multifunctional therapeutic blanket with adjustable weighted sachets for conveniently altering pressure and function of the blanket. The title *TEKK* means blanket in Estonian. It works as an anxiety relief tool based on deep pressure touch stimulation (DPTS). As a play mat, it develops balance skills, mimics a massage, and stimulates tactile senses. The blanket set includes buckwheat and aromatic herbal heat pillows to stimulate smell and tactile senses (Figure 9.7). The traditional weighted blanket aims to calm, promote sleep, imitate a warm hug, and provide a sense of security (SensaCalm, 2015). *TEKK* can be used by people

Figure 9.6. *TEKK* by Kris Veinberg and Egle Lillemäe is a multifunctional buckwheat blanket that, besides its calming effects, invites playful interaction. Photograph: Kris Veiberg. © Kris Veinberg, Egle Lillemäe, and Estonian Academy of Arts.

Figure 9.7. The buckwheat sachets filled with additional scented herbs in *TEKK*.
Photograph: Kris Veinberg. © Kris Veinberg, Egle Lillemäe, and Estonian Academy of Arts.

of all ages at public institutions, such as hospitals, as well as in the home environment. It uses buckwheat, a local material often used in therapeutic buckwheat hulls pillows (RemedyWay, 2017), of which both the hulls and the seeds can be used to achieve different weights of sachets (Tõrvaaugu Organic Farm, 2017).

TEKK builds on the prior knowledge of the benefits of weighted blankets for calming over-stimulated children and adults (Mullen, Champagne, Krishnamurty, Dickson, & Gao, 2008; Vaucelle, Bonanni, & Ishii, 2009; Venosa, 2016) and the benefits of buckwheat as biodegradable and natural, breathable, hypoallergenic, long-lasting, and therapeutic (Buckwheat Hull Pillows, 2014).

The main material of *TEKK* is cotton supplied by a manufacturer of hospital bed linen. *TEKK* is 120cm x 160cm in size, containing 25 pockets with closures using elastic bands that fit 25 zippered sachets, each 20cm x 25cm weighing 500 g. The maximum weight for the blanket is 12.5 kg. *TEKK* has an additional four heat pillows of slightly different sizes and inserted anti-anxiety herbal scents, such as star anise, chamomile, and lavender.

The student team who developed *TEKK* worked persistently with a clear vision on the buckwheat blanket idea. Next to the weighted blanket prototype they considered several other blanket-style concepts that were developed up to a certain extent. However, in the end the team decided to focus on one item and its presentation.

Testing Prototypes in the Context and Feedback

To better understand the context and improve the designs, the special needs educator working with her client tested all of the student works in the children's hospital. The client is a boy, 6 years and 2 months old, with autism and attention deficit and hyperactivity disorder. He has language perception and communication difficulties. The students could observe how the client reacted to their design prototypes.

When introduced to *UUDU*, the child was excited to see many colors and textures and immediately touched and pressed different materials (Figure 9.8). He enjoyed reorganizing the textile swatches on the board and found out by himself that the materials can be changed on the rollers. He was most intrigued by a sample that had soft, shiny, and hard materials mixed in one. Matching colors of the pillow and board did not retain his interest for long; it seemed to be too easy a task for him.

Figure 9.8. A child discovering *UUDU*, matching colors with the soft wheel, organizing the swatches on the back of the box, changing the roller swatches, and feeling them. Photograph: Helen Grass, Irina Pommer.

Figure 9.9. *TEKK* and *SHPACO* in the Childrens' Hospital testing room and the special needs educator introducing them to the child. Photograph: Kris Veinberg. © Kris Veinberg, Egle Lillemäe, Maria Teng, and Estonian Academy of Arts.

The special needs educator involved in our project liked the textile swatches on rollers. She pointed out that the game was perhaps cognitively too simple for the child, but he enjoyed the tactile aspects of the textures and the possibility of changing the cover of the rollers with Velcro. In her view, *UUDU* could be used more successfully with younger or cognitively less-developed children for enhancing their visual perception and their creation of associations. *UUDU* therefore works for improving tactile sensing, raising, and lowering sensitivity in children of all ages and levels of development.

The *SHPACO* play mat was not completely finished when it was tested in the hospital (Figure 9.9). All the lights illuminated when it was stepped on, but not all the functions worked at that point. Nevertheless, it was interesting for the child. During the testing, he discovered a new game by stepping on soft buttons embedded under the shapes and the lights were then turned on. So when he wanted to keep the light on, he learned that he had to step from one shape to another without leaving the shapes in the meantime. It was apparent that the development level of the child would have allowed the actual game to be played. Therefore, the special needs educator was confident that the game, when ready, could be played successfully by children of a similar age group and learning ability and would enhance the children's learning of colors, shapes, and patterns and of how to balance their bodies.

As *TEKK* was taken to the hospital's multisensory room one week before the testing day, the special needs educator and other hospital staff were able to familiarize themselves with the prototype beforehand (Figure 9.9). Overall, the user experience during this week was positive. The special needs educator mentioned that children came up with new ideas and uses for it, for example, pillow fight, hide-and-seek, building a pillow castle, etc. The hospital staff also used it as a weighted blanket to reduce stress. The children used the weight function by placing individual pillows on themselves rather than the blanket with pillows. In addition, the weight function of the whole blanket was successfully used once to calm down an agitated three-year-old child. During the testing session, the child was playful with it and noticed straight away that it is for lying down and he started to play a fantasy game (day and night). It is worth noting that the students did not foresee that bringing *TEKK* to the multisensory room one week before the testing day would influence the user's experience during the testing session.

According to the special needs educator, *TEKK* was used in multiple ways during the week it was in the multisensory room, not only by the clients but also by the therapists and other hospital staff. For the clients, they sometimes took the sachets out from *TEKK* and placed them on their laps, until they felt more comfortable. The children built different forms and constructions. They played peek-a-boo, hid things in the pockets, for example, hiding photos of animals in order to group them into types of animals. Children also hid their own feet into the pockets. In some sessions, the pillows were thrown towards each other. *TEKK* was also used for an obstacle course game. The work therefore represents a clever use of local natural materials and the upcycling of textiles, which keeps the cost of production low, to create a product with multiple functionality. An actual link created by the students with the industry (buckwheat and textiles) gives the project extra value.

The insights from testing and interacting with the special needs educator and the child allowed the students to finalize the projects. *UUDU* was improved with even more textile swatches, allowing the users to experience wider spectrum of tactile and visual sensations. *TEKK* included additional scented sachets and an instruction manual to communicate the various ways it can be used. *SHPACO*'s interaction program was finalized with the option of switching between different difficulty levels.

As seen from the *TEKK* example—one week of testing in the actual environment brings up additional uses not originally envisioned by the designers, and the staff familiarizing with the prototype can lead to more insightful feedback. All the prototypes will be used in the hospital multisensory room from now on. After six months a meeting will be held to discuss how the prototypes have been used in the hospital context and what the design-researchers can learn from the long-term use.

Conclusions

The social design project, where textile design students learned about children with special educational requirements and interaction design, provided new equipment for the special needs educators in Tallinn Children Hospital. It started up a conversation on how to enrich the learning experience of children with various spectrums of attention sensitivity between special needs educators, children, textile design students, and researchers. The joint project resulted in three interactive textile prototypes for the hospital's multisensory room, where the special needs educators continue to use them in their daily work with their clients.

From the brief one-day trial in the hospital's multisensory room, the special needs educator evaluated the developed interactive textile-based prototypes to diversify the child learning activities. She recommended that the students introduce their work to other institutions with multisensory spaces that might benefit from the work.

In addition to achieving high-level interactive textile-based prototypes, the students experienced the benefits of multidisciplinary teamwork by including family members and friends with knowledge about the context of special education, electronics, or materials. The students iterated very successfully between the material and context development, for example, simultaneously improving the game ideas and patterns for recognition, programming interaction patterns as well as building the electronic textile prototype. The students used their initiative to find locally produced materials (buckwheat) and entered into conversations with the producer. The collaboration might continue beyond the student project at the Estonian Academy of Arts.

Iterating from a prior workshop on soft switches into the social design project, prototyping was challenging for most of the teams. Working with soft electronics materials to create work in a larger surface and diameter is much more complicated than in small-scale work. Not everything works as predicted, nor can it necessarily be scaled up. This differs from what the students are used to when working with more traditional materials. It would have been useful to provide programming help to the textile students throughout the project as this turned out to be one of the barriers for further idea development.

All in all, next to the diverse learning opportunities in the context of social design, interaction design, e-textiles, and other materials, the students consolidated the separate subject areas successfully in their project prototypes. Additionally, they extended their professional network through the connections provided by the class as well as those they organized themselves. They improved their visual and oral presentation skills by taking photos and videos of their prototypes as well as presented their concepts in various contexts (e.g., hospital, academy, advisors, collaboration partners, etc.). The project has demonstrated that textile design can extend its territory beyond its traditional use. Using textile design for a new contextual application such as social design, the project has broadened the student's view of their future opportunities and the contexts in which they can contribute their knowledge and skills. The creation of teaching and therapeutic tools for aiding and educating people with special needs is not new. The market for these kinds of products exists, as can be seen from trade fairs such as REHACARE Exhibition (www.rehacare.com) and companies such as Rompa (www.rompa.com) that has manufactured such products for over 30 years. What is new in this project is that it shows ways in which textile professionals can offer more personalized, environmentally friendly, and affordable products to this market.

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