# Smart Materials as Material, Tool and Method

Nanna Jansen
PIT-CAVI
Aarhus University
Helsingforsgade 14, Aarhus, Denmark
+45 2829 8464
nanna_jansen@hotmail.com

Pernille Grand
PIT-CAVI
Aarhus University
Helsingforsgade 14, Aarhus, Denmark
+45 2874 4123
pernillegrand@gmail.com

## ABSTRACT
In this paper we argue that smart materials are able to shift between being a material, a tool and a method. With the smart materials we created an interactive leaf and a hugging teddy bear. Making the interactive leaf lead to the realization that smart materials can become a tool for the designer, which has the effect of reducing some of the complexity in the smart materials. The creation of a hugging teddy bear, lead to the smart materials stepping in the role of a design method, being able to successfully remove self-limiting constraints from the design process. Based on our own work with smart materials, we argue that these additional qualities in smart materials only emerge when the designer works hands-on with the smart materials. Consequently the designer has to be aware of the importance of hands-on work with smart materials.

## Categories and Subject Descriptors
D.2.10 Design

## General Terms
Documentation, Design, Experimentation, Human Factors

## Keywords
Smart Materials, Interaction Design, Design Process, Design Tool, Design Method, Constraints

## 1. INTRODUCTION
This paper is primarily based on our own experiences from a design process where we worked with smart materials as a part of a course in Advanced Interaction Design. The paper is a retrospect view of how we came to use and understand smart materials. We went through a design process where the task was to create a design that promoted a local travel agency. During the process we worked with different materials. One of the materials was smart materials, which were presented as a constraint about 2/3 into the design process. In this paper we reflect on our own work with them and discuss how smart materials can serve as materials, tools and methods in the hands of the designer. The point of the paper is not to define the difference between these, but instead what influence it had on the understanding of the smart materials. The process underlined how difficult the design discipline can be in differentiating between tools, methods and materials since many of them seem to be overlapping in different situations. Through our work we realized that it might not be a question of defining these terms, but a question of realizing when this overlap is happening, what can be gained from it, and how to use it to inspire creativity and productivity in the design process. With our work and this paper we argue, that it is essential to work hands-on with the smart materials at hand, because they, due to their complex qualities, lie in a field between being both materials, tools and methods.

Smart materials are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli [8]. Smart materials therefore often have some extra qualities compared to more traditional materials like wood, paper or ordinary paint, which make them very suitable for interaction design. This however also means they can be more complex to work with. By complex we mean that they have qualities that can be hard to predict because they resemble materials you know but also have extended properties, which creates new challenges for the designer [2]. Smart materials can be considered as new materials in two aspects. They are new materials in the sense that they have not existed for as long as for instance paper, but they were also new materials to us as designers in the sense that we had not worked with them before. The latter meant that we experienced some disagreement in the process in how to use the smart materials and incorporate them in an existing design concept. One part of the group believed it possible to predict what the smart materials was capable of and therefore did not need to explore them further, since they did not fit in with the existing design concept. The other part of the group felt there was something to gain from working hands-on with the smart materials. Some of the group members therefore chose to explore the smart materials hands-on and this resulted in the development of a teddy bear and a leaf made from smart materials. These two approaches exemplify Wiberg's [9] point about the distinction between focusing on material studies versus focusing on the system's "purpose".

*Paper presented at SIDER'14*
*Royal Institute of Technology, KTH, Stockholm, Sweden*

## 2. BACKGROUND

The smart materials we worked with consisted of Muscle Wire and Thermochromic paint. Muscle Wire is metal thread, with the ability to shrink when heated. Thermochromic paint works by changing color when heated to a certain temperature. In addition to this, we had normal thread, different fabrics, glue, pen and paper.

We worked with the smart materials as a part of our design process, regarding the production of an interactive branding solution for a local travel agency. Our target group was senior citizens, who were already used to travel. Based on the knowledge about the client and our target group, we set up some core values for our project: personal contact, make the customer feel secure, locally oriented, easy and low-tech interaction and attentive and outreaching guides.

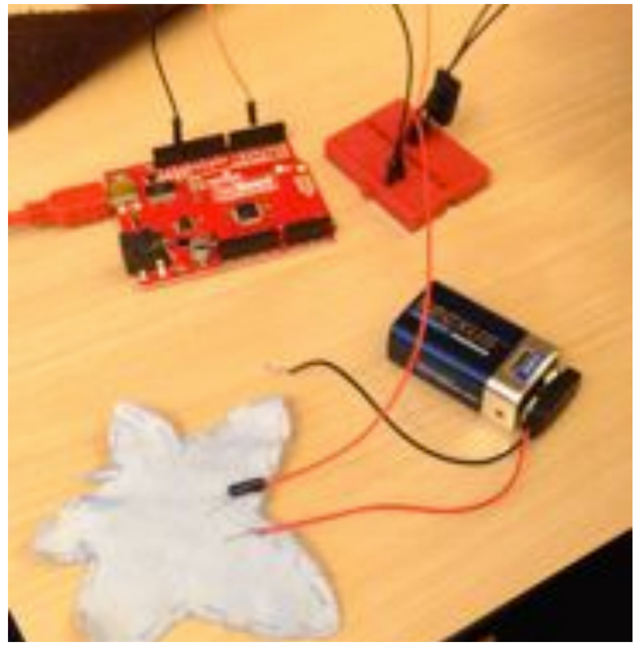
We were presented to a project made by our lecturer Lasse Steenbock Vestergaard, which consisted of a tree build from smart materials. Part of this project concerned how to make a leaf that was able to change color and curl up, as if it was wilting. Our first task was to make our own leaf, and hereby experience the challenges related to this. In the second part of the course, we got free rein, and were able to use the smart materials to whatever we wanted. This resulted in the creation of a hugging teddy bear.

## 3. SMART MATERIALS AS A TOOL

In this section we explore how tools were used in practice [7]. We argue that when working with the leaf, the smart materials took the role of a tool, and we explore what this meant to the understanding of smart materials.

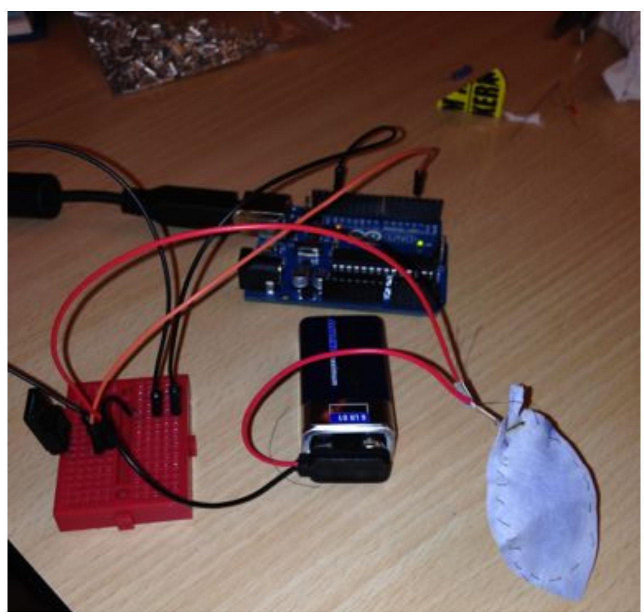
The leaf was interactive in the sense that it was able to curl up and change colors depending on values from the computer. The leaf was made from fabric painted with Thermochromic paint. The painted leaf was then sewed with Muscle Wire along the rim and the Muscle Wire connected to an Arduino. Through the Arduino sketch values are send through the circuit. The higher the value the higher the effect visible on the leaf. The leaf reacts by changing color, since the Muscle Wire heats it up, and also by curling up.

The first thing we did when presented to the task was to start designing the shape of the leaf. We first made the leaf in a maple leaf shape. We thought this would have a nice effect when the leaf curled up. But it turned out later it had the opposite effect. Because of this we had to redesign the shape to a simpler beech leaf shape. This also meant we had a second try in sewing in the Muscle Wire the most optimal way. Between these two tries we had a couple of test runs. It was the first time we were working with Muscle Wire, which meant that we had no idea what would lead to the best effect.



**Picture 1. The first leaf set-up**

This example states some obvious reasons to work hands-on with smart materials. For instance the Muscle Wire we used had the disadvantage that, if heated for too long, it would overheat, break and thereby be a serious fire hazard. By experimenting with the leaf, we detected this, which led to a great amount of caution when building the teddy bear. Having this knowledge we were aware not to activate the Muscle Wire for too long as this would break the wire and could lead to material going into flames. This is an example of knowledge we had not obtained if we had not explored the smart materials hands-on.



**Picture 2. The second leaf set-up**

During the process of making the leaf, we only used the fabric, the Muscle Wire and a needle. From time to time we tested it with the computer, but the process was very focused around the smart materials themselves. We argue that this meant that the smart materials actually went from just being materials to becoming the tool as well and that this helped reduced some of the complexity of the Muscle Wire.

During the process we were very focused on making the leaf react as much as possible and it was not until later on we realized what the tool aspect had meant for the process. As stated, we did not use a lot of other tools to make the interactive leaf. We used the actual smart material (Muscle Wire) to sew directly in the fabric. This meant that we were able to focus only on the materials and that meant that the smart material was a material and a tool at the same time. To clarify this we can give a simple example. When building a box the wood and the nails are the materials and the hammer is the tool. In our case the fabric and the Muscle Wire originally were the materials but at the same time the Muscle Wire were also the tools to make the leaf.
What this meant for the process can be split in two aspects. First it made us very aware of the qualities of the material for instance how bendable the Muscle Wire was. The line we sewed in was depending on how bendable it was and that way the qualities of the Muscle Wire as a tool became significant for its use as a material. Its tool-like role therefore made us aware of qualities in the Muscle Wire we elsewise had not noticed. Secondly when the Muscle Wire became a tool, it immediately inherited the characteristics of regular needle and thread. This meant a reducing in some of the complexity in Muscle Wire as a smart material. In the same way that we do not need to reflect on how to use a hammer, we did not need to reflect on how to use the Muscle Wire. The Muscle Wire went from being an unknown, new and complex material, to being a tool relying on our tacit knowledge. This can be compared to a kind of hardware sketching as Holmquist [3] refers to, which is an interesting point. In classical sketching you use pencil and paper to create a drawing OF a design, while hardware sketching works more as an intermediate stage ("trial version but now in hardware") - we argue that we here experiment directly with the material - the material and tool becomes a "whole" by the crafting element.

## 4. SMART MATERIALS AS METHOD

Being faced with the second part of the course, the assignment was to use the smart materials to whatever we wanted. This lead to the realization that smart materials can be understood as a method as they can help the designer remove constraints during the design process. Being unable to build our current design concept with the smart materials, we were forced to start from scratch, explore the possibilities of these new materials and come up with a new design concept. Finding our self in a situation where new ideas had to come into play, we got inspired from the things at hand.

We had previously in the design process played around with thoughts about an interactive souvenir, linking the holiday to the company, but without being able to concretize and externalize it into a specific design concept. Being constrained by the materials at hand, we got inspired by the Muscle Wire and some soft fabric to make a teddy bear, with the ability to hug.

**Picture 3. The teddy bear**

The figure of the teddy bear led to a bunch of new design ideas; making the teddy bear able to record and in that way being an auditory travel diary, linking the look of the teddy bear to the life size mascots used to entertain children on the holiday location and making the teddy bear able to tell the travel stories of previous travelers.

As a result of having to incorporate the Thermochromic paint, the name of the teddy bear should be written on its stomach in a way that it only showed up after hugging it, and thereby adding heat to the paint. The actual functionality of the teddy bear did not turn out as planned. The Thermochromic paint was too sensitive and just the room temperature was able to make it transparent. The way we had sewn in the Muscle Wire, and the small amount we used, only made the teddy bear able to make a very small gesture with its arms. This could only be linked to the movement of a hug using a lot of imagination. The actual profit of the work, turned out to be more about the creation of new ideas and the work with our values, than on the functionality of the teddy bear.

## 4.1 Using Smart Materials as Constraints

Working with the materials put us in a situation with a lot of constraints, given us no other choice than to scratch out temporary design concept and reconsider our design values. At this point in the process, the complexity of the smart materials both had the role of being a constraint, and at the same time making room for a new view. As stated by Stolterman and Janlert, sometimes complexity can be a useful richness, which is how we see the situation in retrospective [4].

The smart materials were an imposed constraint, whereas our design values and target group were self-limitation constraints [1]. The complexity of the smart materials forced us to overlook some of our constraints. Onarheim mentions this as a way to open up the creative process, by removing one or more constraints [6]. Onarheim suggest this, but gives no guidance in actually practicing this and based on previous personal experiences removing an important constraint can be a big challenge, as it tend to always be in the back of the mind trying to break through again. One of the most important constraints in our design process was our target group being senior citizens, which induced several constraints; the design had to be simple, and focus on personal contact and security/comfort was of big importance. Being faced with the constraints of the smart materials, we were forced into letting go of some of our previously self-limiting constraints. Being focused on using the smart materials and limited by the constraints the smart materials contained, we were able to set aside one of our most important constraints; our target group being senior citizens. Based on the associations linked to the materials, we made a product more applicable to children.

Based on this experience, we argue that the smart materials can step into the role of being a method. A method understood in the way of that it helps the designer to move forward in the design process [5]. Here the smart materials became a method in just this sense, which served the purpose of successfully conducting the removal of a constraint. This gives space for a creative process, which can help the designer if she is stuck in a design process or to help her overcome design fixation [5].

# 5. CONCLUSION

As we have argued throughout this paper, smart materials have the quality of being a material, a tool and a method. The discussions regarding what covers the meaning of a material, a tool and a method is not something we will respond to in this paper. What is important for us is not the definition of these words, but the possibilities Smart Materials hold and how these advantages only arise by conducting hands-on work. This relates to the group disagreement mentioned earlier, and the later agreement in the group that smart materials needs to be explored hands-on. Looking back on the experience, we agreed that the way to understand smart materials is through working with them. This also relates to the smart materials being able to take these different roles - which are only possible through working hands on with the smart materials.

# 6. ACKNOWLEDGMENTS

Our thanks to Nicolai Brodersen Hansen for an interesting design course and help finishing this paper. Also thanks to Lone Koedfoed for help with the paper and to Lasse Steenbock Vestergaard for help with the smart materials.

# 7. REFERENCES

[1] Elster, John: "*Ulysses Unbound:Studies in Rationality, Precommitment, and Constraints*." (2000)

[2] Fernaeus, Ylva, and Petra Sundström. "*The material move how materials matter in interaction design research*." Proceedings of the Designing Interactive Systems Conference. ACM, 2012.

[3] Holmquist E. L. 2006. *Sketching in Hardware*. In interactions - The art of prototyping, Volume 13 Issue 1, pp. 47+60

[4] Janlert, L. PE., & Stolterman E. (2010). *Complex interaction*. ACM Transactions on Computer Human Interaction (TOCHI), 17 (2) 8

[5] Löwgren, Jonas, and Erik Stolterman. *Thoughtful interaction design: A design perspective on information technolog*y. Mit Press, 2004.

[6] Onarheim, Balder (2012): *Creativity from constraints in engineering design: lessons learned at Coloplast. Journal of Engineering Design* 23, 4 (22 February 2012), s. 323-336

[7] Stolterman, Erik, and James Pierce. "*Design tools in practice: studying the designer-tool relationship in interaction design*." Proceedings of the Designing Interactive Systems Conference. ACM, 2012.

[8] Vallgårda, Anna, and Johan Redström. "*Computational composites*." Proceedings of the SIGCHI conference on Human factors in computing systems. ACM, 2007.

[9] Wiberg, Mikael. 2013. *Methodology for Materiality: Interaction Design Research Through a Material Lens*. Personal and Ubiquitous Computing, 1-12.