The knowing body in material exploration

Camilla Groth, Maarit Mäkelä

camilla.groth@aalto.fi

Aalto University, School of Art, Design and Architecture,

Department of Design

P.O Box 31000, 00076 AALTO, Finland.

Abstract

The role of the body is not yet fully recognized in the process of knowledge creation. In the creative fields, especially in the field of art, craft and design, the manipulation of material is essential and much of the knowledge created in this process is generated bodily. This paper explores the role of the knowing body in material exploration. In order to investigate this theme, we gathered drawings, diaries as well as weekly and final reflections from MA-students during the Personal Exploration and Experimentation course (DEE) at the Aalto University, School of Art, Design and Architecture, Department of Design in Helsinki, Finland. The course supports the students' own explorative process from concept to artefact, often via extensive material explorations. The course has been offered since 2009, and for this research we have analysed the data gathered from years 2013 and 2014, that involves 19 students in total. In this paper we study two students' material exploration processes in detail, from the point of view of their embodied engagement. The findings suggest that previous material experiences gathered through our body, guide us in material exploration even before physical manipulations start. Tactile impressions and images of materials are key in the choice of materials. The physical manipulation of materials help resolving complicated spatial design problems as the design is taken into the lived experience.

KEY WORDS: Body; experiential knowledge; material exploration, design practice; Education.

Introduction

The role of the body is not yet fully recognized in the process of knowledge creation in today's society, where cognitive abilities are valued and stressed (Claxton, 2012, 1). In contrast to this, especially the creative fields, including art, craft and design, are

concerned with knowledge generated through bodily interaction with material. This experiential knowledge relies on sensorial information that is situated, subjective and often implicit, evading explicit formulations (Niedderer 2007, 2010; Biggs 2002, 2004).

Considerable amounts of research in the art, design and craft field is focused on investigating the possibilities of gaining knowledge through making, and reflecting on the produced artefact (Mäkelä 2007; Biggs 2002, 2004; Niedderer 2013). In contrast, only little attention has been attributed to the body in the formation of knowledge in this context. Through the emergence of embodied cognition studies, (Varela et al. 1991; Noë 2009, Lakoff & Johnson 1999; Johnson 1987) the theoretical ground is laid for including the body in the knowledge generating process also in the field of art, design and craft. Although art and design fields to a large degree involves the senses and the performance of the body in daily practices, only few researchers have touched the issues of embodiment in connection to design and material exploration (For examples see e.g. Rompay 2013; Fredriksen 2011; Kangas et al. 2013; Ojala 2013; Groth et al. 2013; Groth et al. 2014). While the embodied cognition studies have not yet considered design issues properly, design studies have just recently started considering issues of embodied cognition.

This paper presents two material exploration processes that took place in an educational context. The students were participants of the Design Exploration and Experimentation course (DEE) at the Aalto University, School of Art, Design and Architecture, Department of Design in Helsinki, Finland. Some of the themes that emerged from the analysis were touching issues like; the students' use of their previous embodied knowledge in overcoming challenges with new materials; the importance of tactile aspect and the use of the touch sense in the decision making process regarding materials; the felt experience of materials and its' link to emotional feelings as well as shared social and ethical values. Most importantly, an "imaginary" material exploration was detected to precede the physical material exploration.

In this paper we focus on this imaginary material exploration in between the sensitive transition from 2D to 3D in the design process. We discuss how the phenomena may be seen from the point of view of embodied cognition. We will next present the theoretical frame that has informed our study by discussing how embodied cognition is rooted in phenomenology and the study of experiential knowledge. Then we link this way of thinking to how embodied cognition might be understood from a

practitioners point of view in the field of art, craft and design. After that, we will describe our research setting and discuss the two cases in detail.

The knowing body

Many fields, not least the creative art's, are based on implicit knowledge that is intuitive and immediate, without apparent reasoning. This may seem as not requiring the mind to work. For example sports are sometimes mistakenly referred to as occupations that "involves lesser kinds of thinking, or none at all" (Claxton, 2012, 1). The body is thus being perceived of as the non-thinking agent, and the mind as the thinking agent.

This dichotomy is being challenged by embodied cognition theory. Embodied cognition theory is based on the philosophy of the mind, specifically phenomenology that most strongly argues for the knowing body. Phenomenology holds that due to having a body, we are restricted to a subjective view of the world, seen from the perspective of our situated body. The world shows up for us and we perceive it as such through our senses. But since our body is kinaesthetic, we can move to a new position and perceive the world from another perspective. In this way we accumulate our knowledge by movement and interaction with our surrounding. The French philosopher Merleau-Ponty, further developed the idea, especially in his book *Phenomenology of perception* (1962), where he elaborates on the body as the centre of knowledge making and lays part of the foundation for embodied cognition theory.

Through embodied cognition theory we can draw a new image of the body and mind that is perhaps easily recognizable by practitioners in the creative fields. We can suggest that the mind, instead of being situated only in the head, would be distributed throughout the experiencing body. Through our attention we specify a part of the body that is extra mindful at specific times - for example when listening to a specific sound, tasting wine or threading a needle. In this respect we can understand our whole body as a thinking thing as opposed to only our mind being a thinking thing. The mindful or knowing body is the position we argue from throughout this paper.

Towards experiential knowledge

For this paper we investigated the role of the body and haptic experiences in material exploration by utilizing data gathered from the DEE-course. The eight weeks intensive course works as an educational experiment and research platform focusing on design

students' personal creative process and their individual way of managing its phases (Kosonen & Mäkelä, 2012).

Each year around 12 students participate in the course. The course is designed especially for students that study in the Industrial and strategic design program, as in their current curriculum studio-based practices are rare, and individual design projects have often been replaced by group work. However, it seems that the design students benefit from handling processes typical to fine art (see e.g. McDonnell 2011, 569). During the course the students document their process in working diaries and share its phases in weekly reflections. The final outcome of the process is an artefact that is presented in an exhibition.

The students first develop their concepts with the help of different types of 2D drawings and mind maps. This is considered as a typical way for designers to approach design tasks (Goel 1995; Rodgers & al. 2000, 451; Scrivener & al. 2000, 465). When the concept is developed to a convincing stage, 3D material exploration starts. In a few cases material exploration starts in a very early stage, letting the material agency affect the concept creation.

For this study, we first macro-analysed all data gathered during DEE-courses from years 2013 and 2014 involving 19 students in total. Based on this initial analysis, we selected two cases that were closely linked with our theme, i.e. material exploration and in particular, in connection with embodied cognition. The data chosen for the deeper analysis consisted of the two students own diary notes, drawings, photographs, weekly reflections and final reflections produced during the course, one case being from the year 2013 and the other from year 2014.

The students seldom reflect openly in their reports or diaries on their experiential knowledge or bodily interaction with the material. Because of this, we also interviewed the two students. The questions were open questions followed by a directed question based on the themes of tactility/body and material/exploration. The students were not told what themes were searched for in their answers. The transcripts of the two interviews, have been analysed through a thematic content analysis (Fereday & Muir-Cochrane 2006). Furthermore, when related drawings and visuals have been available, they have been utilized to give more depht to the content analysis. The quotes and transcripts of the interviews have been translated from Finnish to English.

The combination of inductive and deductive coding enabled us to take the theoretical aspects of embodied cognition into account in our analysis process. The initial themes were searched for on the basis of our theoretical framing, that is the themes of tactility/body and material/exploration. Subsequently these were developed according to the themes that were emerging from the data.

The themes that emerged from the analysis were touching the issues of how the students used their previous embodied knowledge in overcoming challenges in their meeting with a new unfamiliar material. The artefacts made were found to carry with them embodied memories of felt experience from the time of making. Metaphors were often used in communicating felt experience both in the interview and the students' reports. The tactile aspect of the materials and the use of the touch sense was important on many levels but especially in the decision making process of which materials to use. In the meeting with a new material, the two students referred to skills gained in other materials thus utilizing their previous experiences and embodied knowledge of materials in the overcoming of new material challenges. The felt experience of materials was also linked to emotional feelings as well as shared social and ethical values. A mental material exploration was detected to precede the physical material exploration. In this paper we focus on the latest theme, i.e. the mental material exploration in between the sensitive transition from 2D to 3D in the design process.

Case Antti

The theme of the 2014 years' course was *Journey*. The students travelled to Lapland for five days to gather inspiration for their individual projects. Antti's project became "a journey of material exploration", about the feel of a material and how we are fooled in our senses when the material is juxtaposed and we have a feeling of the material to be somehow "wrong".

Antti has a craftsman's background: he is a metal smith by his first education. He was inspired by the Lappish traditional leuku knife and decided to make one as a starting point for the course. Not having the appropriate material at hand, he made the blade out of aluminium, thinking that it was good enough for a mock up. Making the knife in parts, he only experienced the whole after he had assembled the parts, and was stirred in his senses when he picked up the knife from the working table:

I felt like "what on earth is this?" It looked like a leuku, but when I picked it up it didn't feel like a leuku at all. That weight is so confusing! You just know it is not real.

After this experience he decided to explore different materials (Image 1) from the point of view of what they felt like in relation to their expected use and function: If the Leuku knife would be made of glass, or ceramics, what would it feel like to hold? What would it have left of its' functionality? Would it be a tool, or reduced to a mere concept of a tool, or does it become an art object?

Image 1. Photo of leuku knives in glass, steel, ceramics and aluminium, made by Antti. Photo by Camilla Groth.

Antti writes in his final report that he had known the difference between a real knife and a replica for the tourist industry since he was a child. He thought everyone knew the difference, but was surprised when meeting tourists who thought they had bought a real, functioning knife. He says that even if the knife looks real, you will immediately recognise it as a replica the moment you try to use it.

As Antti started making the leuku knives in different materials, he made a new material acquaintance – ceramics. When confronted with the new material, he was

confused at first, due to the unexpected feel and behaviour of it. The feel of the material gave him a feeling of distrust in himself as a maker. In the interview he says that he had no help from previous knowledge of other materials as the clay was behaving in a completely unexpected way.

> *I had practically zero experience of ceramics. I had no use of my mental skills toolbox in this case; the material was just behaving too differently to what I was used to.*

In his working diary (Image 2) Antti draws an image of the skills he accumulated during his life, naming them his ”toolbox”. It is clear that he has many different kinds of skills and therefore also many skill- learning experiences in his life. During the interview he says, that he is used to trying old tricks and methods that have been proven useful in previous situations, when confronting new materials. He also considers new materials a positive challenge.

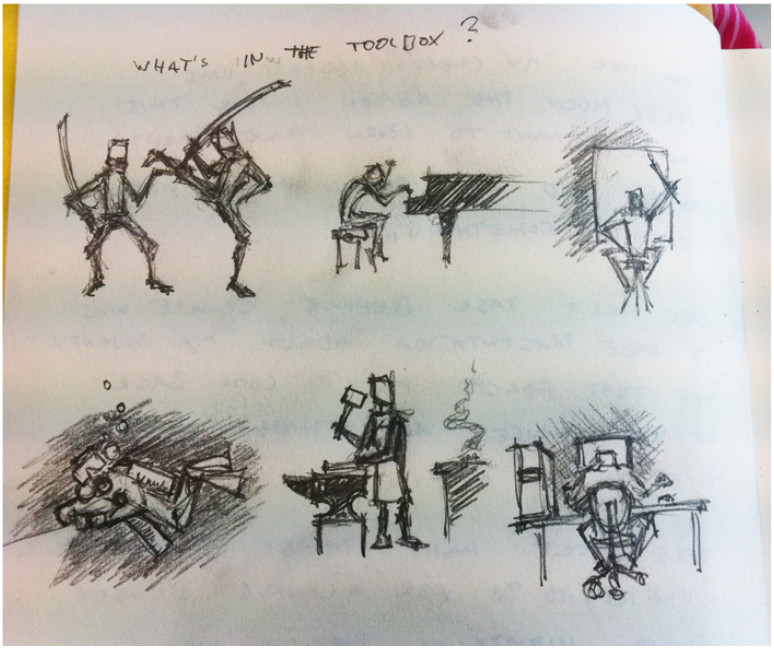

Image 2: Antti’s diary drawing depicting his skills “toolbox”. Photo Camilla Groth.

Although maintaining that the challenge of the new material took him by surprise and that he had no help from his previous experiential knowledge of other materials, he is still clearly using working methods from his own field in tackling the challenge of the new material. When feeling helpless in front of the soft and plastic clay, he waited until the clay hardened a bit. In this way, he was able to *carve* the shape of his knife handles out of the clay, with a knife. He then smoothed the surface with sand paper, utilising the same method he would have used when making wooden knife handles.

In Antti's case, the end result of the course was a selection of leuku's, that create a mixed feeling in regards to the expected feel of the materials, playing on our notion of experiential material knowledge. In the interview, Antti describes the feel of lifting the glass leuku (Image 3):

> *It feels so strange. Like if it was only an idea of a leuku knife. This is like the construction of a knife made by someone who has never known what a knife is used for or who doesn't know what kind of entity uses one.*

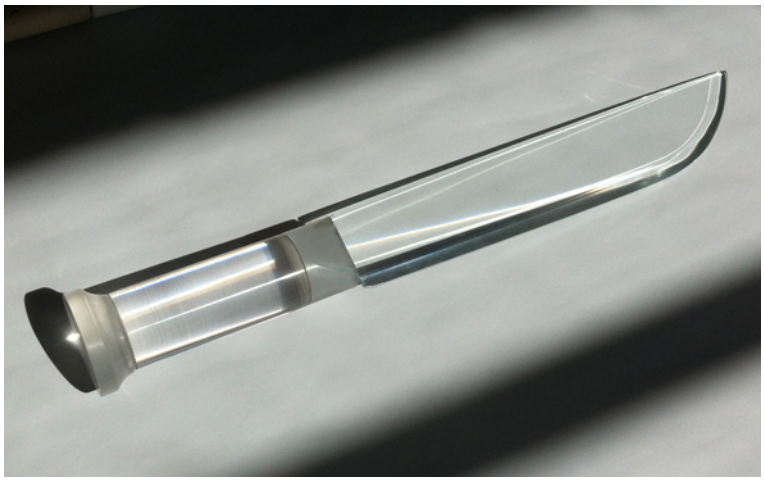

Image 3. The glass leuku knife made by Antti. Photo Camilla Groth.

Case Salla

Salla participated in the DEE course in year 2013 when the theme of the course was *Religion, Belief and Faith*. The course travelled to Heinävesi, a site for Orthodox religion in the east of Finland. She finds her own position as a Lutheran Christian more determinedly in contrast to the orthodox traditions, that to her seem overly artificial and materialistic.

During the course Salla worked on her concept of a *non-God* in response to what she experienced at the Orthodox convent in Heinävesi. The work was based on the idea that the biggest religion in the world is money. She decided to make a natural size golden pig, for the worshippers of this money religion. The material choice for the pig is important and Salla goes to great extent in finding the right "feel" of material that would fit her purpose. The emotional feeling that the finished pig should awake in the audience is the feeling of disgust and meanness, but at the same time of wealth and luxury.

In her working diary she set off her material exploration by listing materials that could be interesting and then striking out the ones that were not disgusting or luxurious enough. She then made four physical models using the four remaining materials on her list (Image 4). In the interview she describes these tests as her most significant material tests, as through them, it was possible to compare the tactual experience of the materials:

> *It was important to make these four small pigs in different materials so that I could get to feel and see them; well most of all to feel them as in the end the way they look is not that different.*

In her final reflection she explains that the small padded pigs helped evaluating the emotional connotations of the materials, such as too kind, too cheap or too nice for her intentions. During the interview she adds that by making tactual pigs, she was also able to let her friends and fellow students feel and evaluate the materials, in this way confirming the social and ethical value and general understanding of the material:

> *And of course, since I had made those little pigs, I handed them to people and asked what they felt and what impressions they got from the material. Which one they found the most disgusting.*

Image 4. Salla's pig shaped test pieces made out of velvet, satin, skin and plastic. Photo Camilla Groth.

In her final reflection she lists the materials and the notions connected to them as a result of her own and her friends opinions. She found that the plastic pig was experienced as the most disgusting but since it was plastic it was also seen as a cheap material and was not experienced as luxurious. Men thought the velvet was most disgusting while women liked it and thought it was comfortable. Skin was agreed to be the most disgusting and mean material.

When Salla had made the decision to go for the skin material, she made a model in plastellina clay. Salla needed a body to model her skin pieces over. But the change of prototyping material, method and mind-set from 2D to 3D was not uncomplicated. A dressmaker from her previous education, Salla was unfamiliar with the large scale she was about to undertake, as well as with the skin as material. Un-used to moulding in clay, she was surprised that the smallest changes in the moulding process changed the entire object. Finally a small model of the pig was made. Salla placed tracing paper over the pig (Figure 5) in order to simulate how the skin will be cut and constructed, and finally sewed into the shape of a pig.

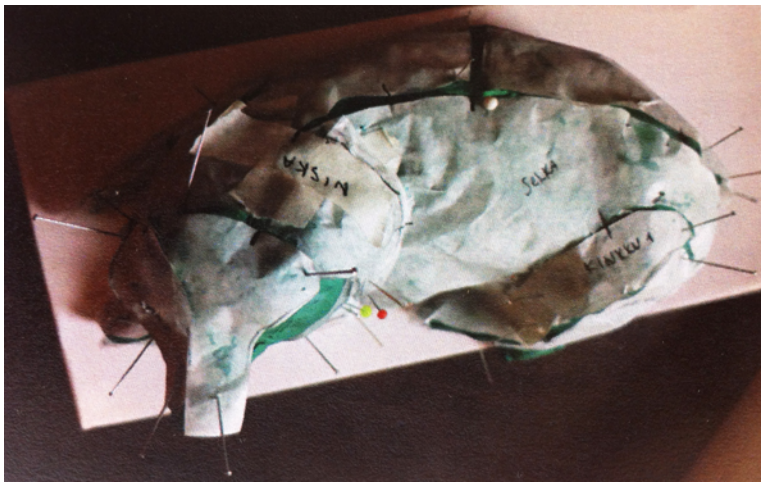

Image 5: Salla's plastellina clay pig. Photo by the student from her DEE course final report, 2013.

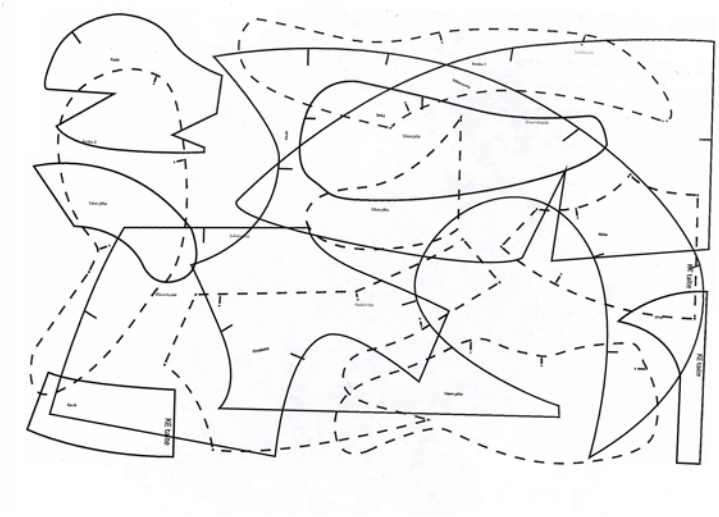

Image 6: Design for cutting the skin parts for the pig. Vector image by from Salla's final report, 2013.

The tracing paper pieces were drawn on a computer converted into vector lines and enlarged 700% (Image 6). The skin was then cut in 1:1 size. When the pieces were sewn together, a new material surprize lingered ahead. The massive amount of skin, eight leather jackets that went into making the pig, weighed tens of kilos. The plan to fill the pig with chicken net and cotton had to be revised and strengthened with a metal construction. The result is a natural size pig (Image 7).

Image 7: The Golden Pig by Salla, photographed in the DEE Course exhibition. Photo by Camilla Groth.

Discussion:

Both Antti's and Salla's material exploration was about the felt experience and the feel of materials. The feel of the materials is connected to emotional feelings evoked by the material, either when viewed or when touched directly. Without previous experiences of these materials there is no pre-knowledge to judge also new experiences against. Both students are working with this type of embodied knowledge, and they base their work on the belief that the viewer shares their general understandings.

Often a material has general connotations that may be utilized in the transferal of a certain feel through an artefact (Rompay & Ludden 2013, 7). Some materials have use-areas that are commonly known and are attributed with expectations of a certain context. Other materials convey an emotion based on what the material feels like. The material feel, links to feelings and emotions that work as motivators or as hindrances of the project. Both Salla and Antti are connecting emotional feelings to the touch-feel of a material. It makes sense that we use the same word "feeling" for emotional feeling and touch feeling.

Imaginary material exploration between 2D and 3D

Before starting the actual testing of materials, both Antti and Salla go through a sort of imaginary material exploration of potential materials. In the interview, Salla reports that she did most of her material exploration in her head:

> *I never really made that many material tests because I was imagining mostly in my mind what the different materials would look and feel like. That's how I reduced my choices.*

She explains further that in this imaginary material exploration, she tried to imagine what the different materials were like. She brought to her mind objects that were made of these materials and their contexts that she had encountered previously:

> *I was thinking of objects that typically are made from those materials, and what images they brought to my mind. Even before I made the little pigs, I listed different materials and their properties.*

Both Salla and Antti list materials in their diaries that they try out in their imagination before making a decision for which materials to include or exclude in their physical material exploration. In Salla's diary, the chosen materials are in the process of being

indicated by arrows (Image 8) while in Antti's diary, the chosen materials are circled (Image 9).

Image 8. Salla's diary. Photo by Camilla Groth.

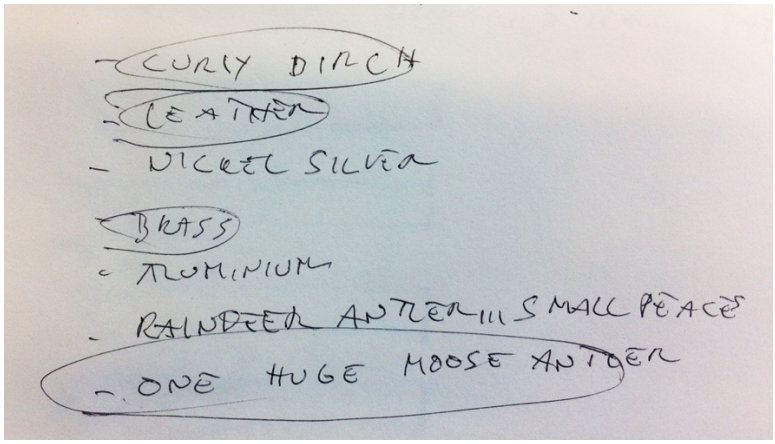

Image 9. Antti's diary. Photo by Camilla Groth.

In our discussion Salla links the touch feel of the material with cultural and social connotations and contexts that are connected with the material generally:

> *It is not only the touch feel, but also the combination of memories and images linked to the materials and in what circumstances they have been seen or what kind of reputation they have generally. For example if it is connected to a bourgeoisie living room like velvet, a shiny BMW like skin or an evening dress like satin. Or then "throw-away" culture as in plastic.*

It is evident that in both of the cases, the imaginary material exploration process is based on previous bodily encounters with the listed materials. The potential materials are not explored in drawing form, but they are listed in writing and then imagined. Both students hold the opinion that materials are too difficult to draw from memory and that a drawing describes a materials properties poorly. In the interview Salla says that drawing takes her to a certain point in designing, but to get to the next level she needs physical material exploration:

> *I see drawing more like searching for a shape and giving shape, the material is what brings it to the next level. Drawing or modelling on a computer is about what it looks like, where to it reaches and how it works. But the material is about what feelings it awakes. Ok, the material is also affecting the way it works but anyway it is the emotional side that is important. By drawing you can of course imitate materials but it is never at all the same.*

In the interview, Antti describes the same problem:

> *How would I be able to draw a material? If I draw something that looks like glass on paper, I imagine what it looks like, how it reflects light and what I can see through it, but it still doesn't convey anything about the material. It is only imagination. (...) The information that a drawing can convey is much more narrow compared to what the artefact conveys.*

In both cases the selection of materials are imagined as lived experiences and applied mentally as the material of the new objects that are envisioned. In this process some materials are deemed not worth trying and others are considered for being tried out in physical form. The final decision of which material to take further is in Salla's case determined by touch. Only after physically confirming her imagined experience of the materials, she made the final decision to go with skin as her material. In the interview Salla reports:

> *What finally determined my choice was the way the material felt in my hands. Because it confirmed my image of it and the connotations the material conveyed.*

Touch thus played an important role in the decision making process as it confirmed the imagined image of the material. Salla goes on to explicitly say, that vision is giving only half of the perceptive view, and touch fills the missing part.

> *Touching confirms what is expected, especially with familiar materials. If the materials are new, then one might have some expectations that can become different after actually touching them. It's like you get only half by looking and remembering and then holding it completes the impression.*

Pirita Seitamaa-Hakkarainen (Seitamaa-Hakkarainen 2000, Seitamaa-Hakkarainen & Hakkarainen 2001) developed a model around the design process as relying on two spaces. The first of them is composition space, i.e. visual, 2D space, that includes shapes, patterns and colour. The second is construction space, i.e. technical, 3D space, including materials, construction and technical details. According to Seitamaa-Hakkarainen, this *dual-space search* shows how the designer is moving between the 2D and 3D spaces during the planning and making of her designed artefact.

As a result of this case study we would like to introduce an extension to this model, as we found one space in-between: the imaginary material exploration that happens in the mind before actually testing materials. In the imaginary material exploration space, materials are explored pre-physically, during which important choices in regards to the materials are made. These choices and decisions are made based on previous bodily experiences and shared conceptual notions of the materials in question. This is a feature also seen in many of the other DEE students, as they dwell in this space between 2D and 3D for a considerable amount of time, before taking physical action. Nevertheless, the very final decisions on materials are taken during physical material exploration.

3D, the lived experience

When the physical material exploration is introduced, the design switches modality and enters our physical world of lived experiences. The 3D object has many sides and surface, some of them are on the other side from us, allowing us to see the whole object only through interaction with it and by turning it in our hands or by walking around it. In line with phenomenology, our knowledge making process is thus subjective and linked to the kinaesthetic ability of our bodies, as we gain knowledge by acting with our environment. We can see some of these elements in our student's experiences of producing three-dimensional material objects or prototypes. For

example, in her final reflection Salla describes her process of transforming the 2D drawn idea into a 3D plastellina clay pig model:

> *From having drawn the pig several times I had a pretty good idea of what I was about to make, but the three-dimensional realisation - expectedly - took it to a new level. The plastellina clay pig revealed challenges that I could not have imagined with my pen and paper. The smallest changes in the form made the pig look like a dog or a cow.*

Design researcher Kaiju Kangas (Kangas et al. 2013) describes how the bodily interaction with a prototype aids in a problem-solving task in co-designing. In her study, children were co-designing a lamp, but it was only when the children made the 3D prototype, that they were able to resolve the problem of the hanging construction that had puzzled them during the 2D design process. The children used their bodies in measuring of distances and heights for the lamp and even climbed up the table to envision how the lamp would hang (2013, 39).

In a similar way also Salla was able to resolve the unimaginable aspects of her design by exploring them physically. Having made the plastellina clay model of the pig, Salla is fitting strips of paper over the model in order to envision how she needs to cut the skin material and where the seams might go (image 5 and 6). In her final reflection she points out that this would simply not have been possible to do in two dimensions:

> *The assembling of tracing paper over the plastellina pig model was a useful way of extracting the complicated shape for the skin pieces. The shapes became very strange looking and my two dimensional working methods and imagination would never have been enough to create them.*

Experiential knowledge builds on previous experiences.

In her research, design researcher and teacher Biljana Fredriksen (2011) studies children's meaning making process during their experiences with three-dimensional materials. She found that previous bodily experiences play a part in the sense making of new experiences (ibid. 65). In our case study, both students are using their previous experience and skills in combatting the challenges of a new material. Antti's previous sets of skills might not have been the right skills for the task at hand, but nevertheless the skill of learning skills, aided him in overcoming the unexpected challenges in the sense making of a new material. Antti says in the interview that:

A person, who does not possess any kind of material knowledge at all, will take a long time to learn about any new material.

These findings are indicating the need to acknowledge the knowing body in teaching, and furthermore, the implications of embodied cognition is now getting attention also in the field of education. In line with this development, physisists Marcus Kiefer and Natalie M.Trumpp (2012) are pointing to the importance of real world material manipulation in education. According to them, appropriate sensory motor experiences are necessary for human cognition to develop at the highest level (ibid. 19). They claim further that in line with embodied cognition studies it has been found that sensory-motor interaction with the environment during learning results in more endurable and richer knowledge (ibid. 20).

As crafts persons and designers, we may understand learning a skill as training our mindful hands until they perform better. Our hands, in working with a material, slowly tests, tries, experiences, fails, tries again and in this way *change us* as makers towards becoming tuned in with the material. Enactivist theory, that is an branch of embodied cognition, supports the idea that our interaction with the environment changes us and develops us (Varela et al 1991; Noë 2004, 2009; Hari & Kujala 2009.) Through the feedback of our actions with the environment we gain experiential knowledge that help us recognize and judge future actions.

When learning through experience, we cannot know what something is like without touching it. When we touch a material, we immediately become aware of it. There is not first *sensing* and then *thinking*, but a sense-reflection that is a singular event (Varela et al. 1993, 19). Varela et al. suggest that the nature of reflection, instead of being an abstract and disembodied activity, is rather a form of experience in itself (ibid. 27). Our mindfull hands know the shape, temperature, orientation and surface structure of the material instantly, as if our hands could think.

Conclusion:

In this paper we have acknowledged the role of the body in knowledge creation within the field of design. As a result of our case study we consider material exploration an important part of the students development into a skilful designer. Drawing and concepting aids when determining the shape and the function, but does not come even close to the lived experience, as does the material prototype. Materials have an important role in conveying felt experiences that affects the emotion of the user.

Further, materials have general connotations as we share concepts and understandings about their nature, images and values. Tactile aspects are important in the evaluation of which materials to use, aswell as in evaluating the finished product. During material exploration the student has a possibility to iterate his concepts based on the physical interaction with the material, and while doing so he makes important decisions for the continuation of the project.

Even before the student starts the physical material exploration, an imaginary material exploration takes place, one that is based on previous bodily experience of the imagined materials. When imagination reaches its' limits, the 3D material exploration and prototype takes the concept to the next level, that is the experiential level, where the design may be experienced bodily. When encountered with new material challenges, previous skills and physical material explorations help in making sense of the new material and its behaviour. Physical material explorations thus strengthen the student's confidence in managing new materials, giving the student a wider and deeper skills-toolbox to work with in the future.

Acknowledgements:

We would like to acknowledge all the DEE students, who kindly let us investigate their diaries, drawings, weekly reports and final artefacts. Especially we are thankful to the two students, whos' processes are presented in this paper. The students chose to be presented by their real names. This research is part of the Handling Mind research project, funded by the Academy of Finland (project number 266125).

References:

Biggs, M. (2004) Learning from experience: approaches to the experiential component of practice-based research in: *Forskning, Reflection, Utveckling*. Stockholm, Vetenskapsrådet, 6-21.

Biggs, M. (2002) The role of the artefact in art and design research. *International Journal of Design sciences and technology,* 10 (2), 19-24.

Claxton, G. (2012) Turning thinking on its head: How bodies make up their minds. *Thinking skills and creativity,* 7, 78-84.

Fereday, J. & Muir-Cochrane, E. (2006). Demonstrating rigour using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, 5 (1), Article xx.

Fredriksen, B. (2011). When past and new experiences meet. *FORMakademisk Journal*, 4. (1) 65-80

Goel, V. (1995). *Sketches of thought.* Cambridge, MA: Massachusetts Institute of Technology.

Groth, C. & Mäkelä, M. & Hakkarainen-Seitamaa P. (2013) Making Sense. *FORMakademisk Journal*, 6 (2), Art. 2, 1-12.

Groth, C. Mäkelä, M. Seitamaa-Hakkarainen, P. Kosonen, K. (2014). Tactile Augmentation: Reaching for tacit knowledge. In Y Lim & K. Niedderer & J. Redström, & E. Stolterman, & A. Valtonen (Eds.). (2014). *Proceedings of DRS 2014: Design's Big Debates.* Umeå, Sweden: Umeå Institute of Design, Umeå University.

Hari, R & Kujala, M (2009) Brain basis of human social interaction: From concepts to brain imaging. *The American Physiological Society,* 89, (2), 453-479

Johnson, M. (1987). The body in the mind. The University of Chicago Press, Chicago.

Kangas, K. & Lahti, H. & Ojala, M. & Yliverronen, V. (2014). Käsityöprosessien materiaalinen, sosiaalinen ja kehollinen välittyneisyys erilaisissa oppimisympäristöissä [Mediation and embodiment in craft processes]. In S. Karppinen & A. Kouhia & E. Syrjäläinen (Eds.), *Kättä pidempää: Otteita käsityön tutkimuksesta ja käsitteellistämisestä.* Home Economics and Craft Studies Research Reports, 33. Department of Teacher Education, University of Helsinki.

Kiefer, M. & Trumpp, M. N. (2012) Embodiment theory and education: The foundations of cognition in perception and action. *Trends in Neuroscience and Education,* 1, 15-20

Kosonen, K. & Mäkelä, M. (2012). Designing Platform for Exploring and Reflecting on Creative Process. *Procedia – Social and Behavioural Sciences*, 45, 227-238.

Lakoff, G. & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to western thought.* New York. Basic Books.

McDonnell, J. (2011). Imposition of order: A comparison between design and fine art practices. *Design Studies,* 32 *(6)*, 557-572.

Merleau-Ponty, M. (2010/1962) *Phenomenology of Perception*. Routledge. London.

Merleau-Ponty, M. (1964/2010). The primacy of perception, in *the primacy of perception: and other essays on phenomenological psychology, the philosophy of art, history and Politics.* Ed. Eddie, J. Northwestern University press. Evanston, Illinois.

Mäkelä, M. (2007) Knowing through making: The role of the artefact in practice-led Research. *Knowledge, Technology & Policy*, 20 (3), 157-163.

Niedderer, K. (2007). Mapping the meaning of knowledge in design research. *Design Research Quarterly,* 2 (2), Article nr 903922.

Niedderer, K. (2013) Explorative Materiality and Knowledge – the role of creative exploration and Artefacts in Design research. *FORMakademisk journal*, 6 (2), 1-20.

Niedderer, K. & Reilly, L. (2010). Research practices in art and design: Experiential knowledge and organized inquiry. *Journal of Research Practice,* 6 (2), Article E2.

Noë, A. (2009) *Out of our heads*. Hill and Wang. New York.

Noë, A. (2004) *Action in Perception*. The MIT press. Cambridge, Massachusetts.

Ojala, M. (2013) Constructing knowledge through perceptual processes in craft - art. *Techne Series A,* 20 (3), 62-75.

Rodgers, P.A. & Green, G. & McGown, A. (2000). Using concept sketches to track design process. *Design Studies*, 21(5), 451-464.

Rompay, T. & Ludden, G. (2013) Embodiment in design: on the embodied foundations of meaning and experience in product design. *Conference proceeding at the 5th IASDR 2013 Tokyo Conference.* Tokyo, Japan.

Scrivener, S.A. & Ball, L.J. & Tseng, W. (2000) Uncertainty and sketching behaviour. *Design Studies*, 21(5) 465-481.

Seitamaa-Hakkarainen, P. (2000). *The weaving-design process as a dual-space search.* Department of Home Economics and Craft Science, Research Report, Vol 6. University of Helsinki.

Varela, F.J. & Thompson, E. & Rosch, E. (1991). *The Embodied Mind; Cognitive science and human experience.* The MIT Press, Cambridge, Massachusetts.