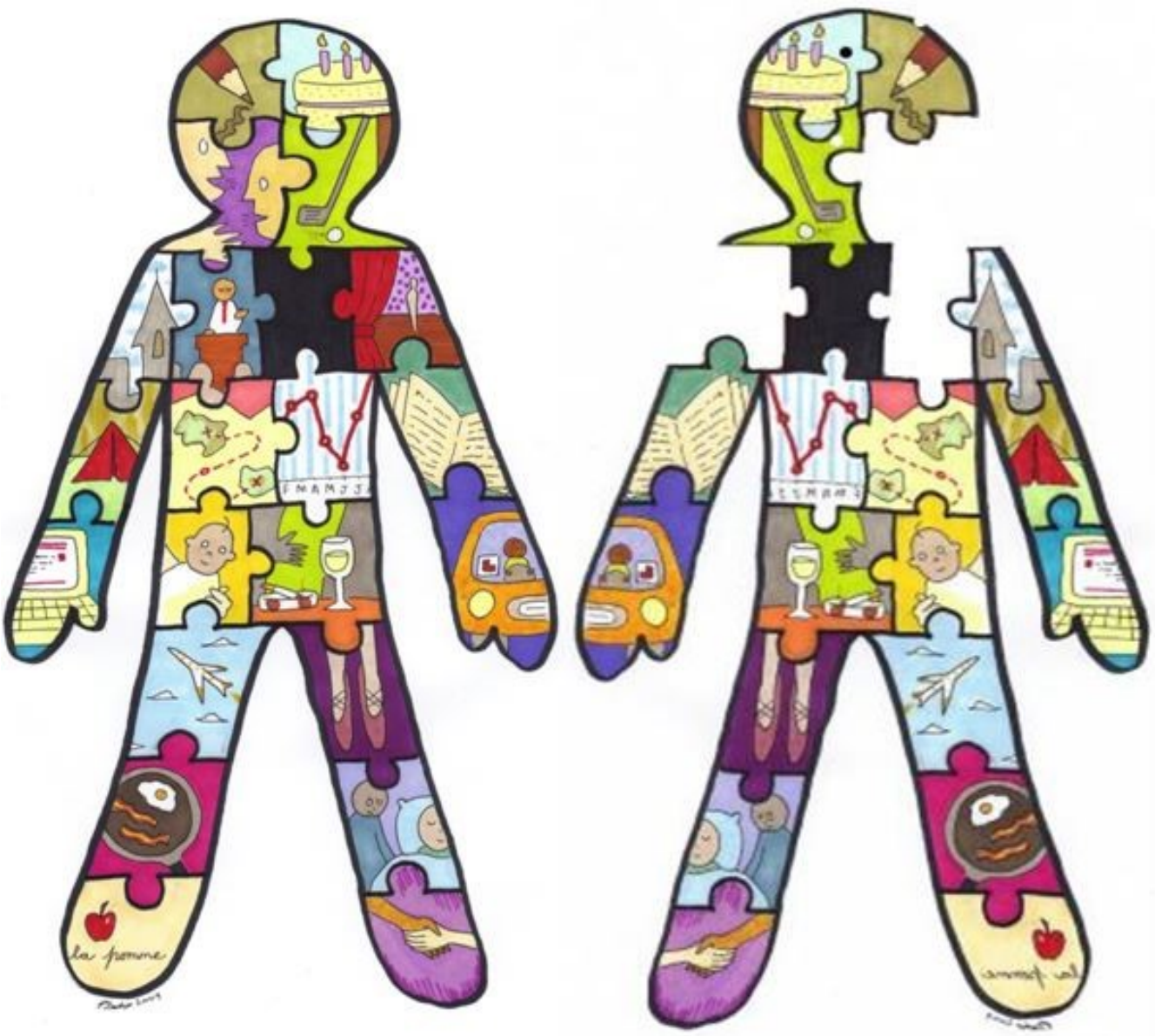

Role of the Body in Creative Processes & Practices

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THINKING THROUGH OUR HANDS

How design & craft practitioners think, make sense and *know* through their hands

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Introduction

Thinking through our hands is not usually what is taught in school, where the body brings the mind to class. However, our mind does not have access to the world without our senses that allow for our whole interpretation of the world and what meanings are out there. Our hands are our interface to the world and body based knowledge is key also in our understanding of more abstract concepts and ideas. Additionally, our imagination and our embodied experiences of the world is needed in our interpretation of concepts as well as making ideas travel further than our bodies. Rather than thinking of the body as separate from the mind, the understanding of the person as a psycho-physical whole is now growing also in education. This article shows some aspects of how the body plays a role in the sense making of design and craft practitioners. These insights are made through studying basic human-environment interactions and they might shed light on the thinking through hands taking place in other contexts too.

Making knowledge

I recently defended my Doctoral dissertation in the field of Design. In my research, I explored the role of the body in sense making with materials that many crafts persons and designers experience in their practice. My curiosity into the bodily aspect of thinking through hands and material was born in my own practice as a ceramist, in which I had experienced a sense of knowing through making but that I could not conceptualize or theorize as yet. Additionally, I felt that my body-based ceramic practice was differentiated from academic knowledge and not valued as equal to conceptually and theoretically based knowledge. Even within the field of art and design there has been a notion of crafts as being unreflective and material based as opposed to the immaterial and conceptual arts or the planning of the design rather than the manual implementation in materials[1:18-19]

I knew by experience that crafts persons think, feel, make judgements, plan and theorize *in action* and in a direct relationship and negotiation with the materials, but felt that this way of making sense was not being distributed to the wider audience, perhaps exactly because we tend to differentiate between practice and theory. In the past craft practitioners seldom acquired the double profession of researcher-practitioner, therefore their practice has traditionally been studied by non-practitioners. However, recently due to reforms in the educational system, higher education including doctoral degrees are offered also in practice based subjects. As a result the number of researcher-practitioners has increased rapidly in the past 20 years. Now art, design and craft practitioners describe and reflect over their practice from an insider's perspective, drawing attention to the many different aspects of their practice that have been foreseen when being studied by historians, ethnographers or social scientists. One of these aspects is the experiential and body based knowledge that only the practitioner herself knows [(see references 2- 17)]

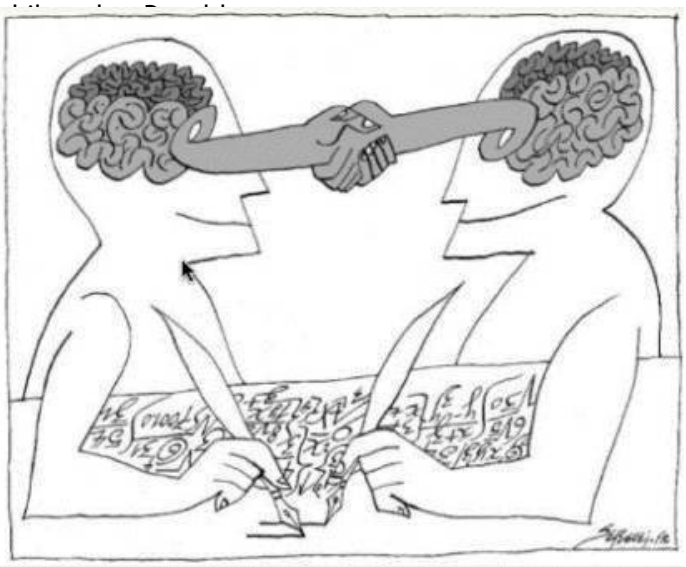
What these practitioners have in common, is that they make something, with their hands using material. We could perhaps describe the act of making something in a material as a conversation, interaction or negotiation between the person and her material environment. By manipulating material, we affect the environment but we are also affected by what we make, or the making experience itself. Making occurs in multiple forms, on many levels and in different contexts. By transforming matter, we even transform society as we make an imprint of our culture and of ourselves on this world. The act of making is thus powerful, as through making we also make meaning, we communicate meaning and we share meaning. In a similar manner, we might think of knowledge as something we create through our interaction with our environment, other people and other peoples' creations of different kinds such as texts, videos, and other artefacts and performances. We *create* knowledge rather than just *receive* knowledge, therefore it is useful to take an active position rather than a passive position both in teaching and being a learner.

Sense-making

The meaning of *making sense* of things is connected to utilising the senses (the body) in the act of meaning making. Philosopher Mikkel Tin[18:1] connects sense-making to the activity of making in a material and speaks for the making activity as a sense-making activity that creates knowledge of another kind than ordinary discursive knowledge. Philosophically, sense-making is a key concept, and it is described by enactivist philosophers in the field of cognitive science, Evan Thompson and Mog Stapleton[19:25] as the organism's (animal or human) activity of transforming the world into an environment that has salience, meaning and value for it. Through searching and finding we make sense of our environment and of what it has to offer, or what it *affords us*. Environmental ecologist Gibson[20:127] explains the concept of affordance in a very similar wording: "The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill" (Italics in the original). Our emotions are central in this sense-making process as they give us cues or gut feelings of how to react to the information we receive[21,22]. Emotions also give our experiences meaning[23].

Sensible senses

We use all our senses, our hands and body in our explorations of the unknown but also in confirming what we already know. Enactivists suggest that a person learns in action and accumulates knowledge through her embodied experiences with her environment; thus, the body is integral in all knowing [24-27] We create our minds through our experiences, and as the brain is plastic it enhances the capacity for what it is regularly exposed to. This means that the more experiences we have of a certain action or interaction, the better we are in anticipating and predicting possible outcomes from future similar actions and interactions. According to enactivist theory also *vision* is an embodied skill, as vision does not make sense to us without our experiential knowledge in relation to what we see [24]. Noë [24] develops his theory around knowing-in-action that concretely ties practice and theory together. The concept of knowing-in-action is also familiar to creative practitioners through the work of pragmatist design theoretician and Schön [28, 29] and particularly his book on the *Reflective Practitioner* [29] (See also Sennett[30]).



Knowing requires action

Another reason for activation is the fact that we activate our brains by moving our bodies. When we sit down our brain thinks we are resting and "turns off" as we do not seem to be in any danger and may relax [31]. Making small drawings or being active in other ways by handling material or small crafts such as knitting while listening to a lecture can yield better learning results than just passively listening to the teacher[32] as this keeps us from getting drowsy and too relaxed. The activity made in this context should be of an uncomplicated sort that has been embodied and automatized enough not to take up too much attention from the listener. Inactivity and restrictions to use our hands may even lower our mental abilities as a large part of our cognitive capacity is bound to the hands[33]. As touching and forming materials such as typically happens in craft activities stimulate these areas of the brain, making in a material or exploring new materials are crucial for developing the brain[34-38]

Sense-making is facilitated through actions or interaction, but we also learn by observing and mimicking others. For example, we *simulate* in order to understand the mental states of others [39]. This ability is facilitated by mirroring systems of the brain[40,41] Mirror neurons, fire in a qualitatively similar way when a person is looking at someone performing an action, to when the person is performing that action herself[42]. That means we empathise with other people's bodily actions. Mirroring systems that support mental simulation and imitation thus also help us learn tacit manual skill as we mimic our peers[35]. This enables tacit knowledge to travel through generations of for example crafts persons who work together in craft communities.

Enactivist theory builds on human interactions with the environment. Human geographers study the interaction between human and her environment, thus, research involving perception is also developing in this field. Gibson[20,43] has been a great influence on researchers that now also link closely to ethnography. Human geographer Paul Rodaway[44] wrote about 'Sensuous geographies' and the idea of the body being a geographic entity is further developed by Mark Paterson[45] in his 'Haptic geographies' where he calls for research methods using the haptic modality. Some strands of anthropology and ethnography likewise expand towards the sensuous realm and human geography through Sensory Ethnography[45,46,47,48,49] Tim Ingold in particular has advanced our knowledge on learning and thinking through movement and making[50]

Representation or lived experience?

The above-mentioned strands of research all link to the non-representational theories initiated by human geographer Sir Nigel Thrift (for an overview, see Anderson & Harrison[51]). Non-representational theories deal with the un-procedural meaning-making that transcends language and other symbol systems, such as visual representations, and that form the situated personal and embodied knowledge and thinking-in-action in, for example, practice-based domains [51:7, 52, 53:646]

Our education system is geared towards the audio-visual sense, asking us to sit still and take in knowledge given by the teacher verbally. But a word is always a representation or a conceptualisation of something, thus it is always a translation of the real thing and not *the same* as the real thing. A word can thus not be experienced physically. However, through drawing on our tactile memory, our embodied knowledge of the thing that the word means, we may recall what that thing felt like. For example, the word *tree* does not open up to a person that has never seen, touched, or climbed a tree.

While our educational system has leaned on a cognitivist approach in the past, the enactive approach is now claiming ground and speaks for embodied cognition also in language comprehension [54] It is not enough to sit on a bench in school and learn about the world outside through language because language is empty without a bodily grounding of the concepts [55] This is clear when it comes to issues describing the material world, but linguists and philosophers George Lakoff and Mark Johnson claim that also the more abstract concepts are grounded in bodily experiences [56,57,58,23]

We also need imagination to understand language[42] and our mind travels outside the classroom as we listen to a lecture, visiting the situations described in the lecture through our embodied knowledge of the world[55] Researchers in the field of neuroscience in relation to education have already picked up on this issue. For example, it has been found that sensory-motor interaction with the environment during learning results in more durable and richer knowledge[36:20] (in this context see also[59,60]). Embodied knowing of materials and their properties were proven essential in the design of artefacts also in my own study that I will describe in the following sections.

Three case studies on tactile experiences

Our hands often form the interface between our mind and the material world. As a ceramist, I use my hands for everything in the studio and the knowledge I have created and stored over the years are embedded in my hands and in my whole body. Thus, when researching my own practice I chose to focus on haptic and tactile experiences in my investigation. The research question of my thesis was: *How do design and craft practitioners think through their hands?* (for a comprehensive description of the study and research settings see my original thesis[61]

I used three case studies to investigate the research question from three different perspectives: I first gained inspiration and a deeper understanding from experts in tactile knowledge, by arranging ceramic workshops for deaf blind people. Learning from these experts, I turned my attention to study my own experiences in my practice, focussing on what I knew through my tactile experiences by blindfolding myself while throwing large clay pots on a turning wheel. In the last case I wanted to know what all this means for design students, therefore I followed a Master course in the field of design and investigated how the students used their body based knowledge in their design and making activities. Although quite different settings, they all focused on haptic and tactile experiences and making sense through material manipulation.

Image 1 Image of myself and the research participant, throwing clay together during the workshop. Screenshot from the video[61]

Learning from tactile experts

As an example of how embodied knowledge may be transferred from one person to another I will here describe what happened in one of the workshops with deafblind participants. One of the participants wanted to make a pot on the potter's wheel, but to facilitate this I would have needed to communicate verbal instructions for how to throw a clay pot to the par- ticipant through his tactile language interpreter. Since the participant normally uses his hands for communicating through the tactile sign language and his hands were now busy with the clay, it was not possible to interrupt his working while giving instructions. I therefore started throwing the clay *with the participant's hands*. I discovered that in the act of throw- ing clay tactile communication was sufficient to pass over to the participant my embodied and tacit knowledge relating to the throwing practice.

Image 2 Image of the research participant, throwing clay independently during the workshop. Screenshots from the video.[61]

Image 1 shows me and the research participant throwing clay together. Even though the research participant could not see or hear anything during the process, he was able to receive my embodied and tacit knowledge of the throwing process. This means: the exact timing and pressure of the hand movements were communicated to him entirely without the use of language. When the research participant had finished this first piece, he tried throwing another piece independently while I was in the next room with the other research participant. The research participant managed to throw a bowl unaided that was almost identical to the first attempt, and I felt that he was unusually successful for a beginner (Image 2).

By utilizing this tactile communication I felt that language was not necessary in transferring this type of body based skill to another person. Visually mimicking another person is normal in transferring craft skills, in this case the research participant was physically mimicking the actions needed to throw clay on the potters' wheel. This shows that also tactile communication methods may be considered in teaching tactile skills, given a mutual agreement between student and teacher. It should also be mentioned that due to his deafblind condition the research participant benefits from his enhanced haptic and tactile sensitivity and his trained tactile memory[62] (This case study is described in Groth, Mäkelä & Seitamaa-Hakkarainen [63]).

Practice-led self-study

The second case study was inspired by the deafblind participants who had shown an enhanced tactile ability. In order to investigate whether I could enhance my own tactile skills and understanding I tried to work blindfolded in my studio for a period of time. I recorded my own practice through several methods, using a diary, video recordings with think-aloud accounts and a contextual activity sampling system (CASS-Q). I noticed that my tactile skills were indeed enhanced over a period of five days. From having felt uncomfortable working blindfolded on the first day I felt quite natural in trusting my hands after throwing clay blindfolded for five days in a row (see image 3).

Image 3 Image of myself throwing clay on a potters' wheel blindfolded. (Image from the video recording of the event[61]

The act of blindfolding as an attempt to augment my tactile sensibility was successful as more attention towards haptic and tactile sensory experiences became available, and I was less interrupted by other impressions. I got used to trusting my hands for information and I became more alert towards my tactile sense and the information coming from my fingertips. I also felt it easier to give verbal accounts of my experiences and what I was thinking while blindfolded.

I noticed that the haptic and tactual feel of the clay and the conditions of the material affected my emotions in either a positive or negative way, especially during critical circumstances. However, I also found that even negative emotions actually helped the process by aiding concentration and focus on solving problems. The heightened alertness, stress and worry about the risky moment of the process involved, afforded extra sensitivity and an attunement to the material that the critical incident called for. This made me aware of emotions as important regulators and moderators in the process of handling difficult material manipulation processes.

Theory related to embodied cognition supporting this hypothesis is linked to the concept of somatic markers[22] Our previous experiences are stored in our bodies as feelings that emerge again in new similar situations. These somatic markers give hints on the available opportunities (affordances) and risks related to a situation. Emotions and sensory experiences are thus linked to the skills and sense-making of a craft practitioner and as such contribute to the embodied knowledge of a practice. (This case study is described in Groth, Mäkelä & Seitamaa-Hakkarainen, [64] and Groth[65]).

Design students' learning experiences

The third case study involved analysing design students' haptic and tactile experiences and sense-making during a course that promotes material exploration as part of the creative process. Two students, were studied closely and their material exploration was documented on a weekly basis. Both students were using their touch sense in various situations during their explorative process. The tactile aspect of the materials that they used were important on many levels but especially so in the process of deciding which materials to use for the designs. Their felt experiences of materials were often linked to emotions and shared social and ethical values that they connected to their mental image of the material.

Image 4 Image of students material tests[61]

However, also a *mental* material exploration was detected as both students listed materials in their diaries that they tried out in their imagination, before trying them out physically. As I interviewed them, one of the students said that she did most of her material exploration in her mind. As these materials were familiar to her it is assumed that she was reverting to previous physical experiences (embodied knowledge) of these materials, gained in other contexts.

Emotions also surfaced in this case study and was linked to manipulating material as it affected both students' self-esteem and image of themselves as practitioners. As the students experienced new materials in their exploration process, the new and unfamiliar material behaviour disrupted their workflow and made them question their skills and at the same time also their identity as makers. The students' anxiety was soon overcome through resorting to familiar patterns and methods of solving material problems known to them from other domains that were more familiar to them. (This case study is described in Groth & Mäkelä[66]).

Concrete knowing through material interaction

Especially in the third case, I could see that the students moved between representational and non-representational making modes. The initial mental image of the intended artefact was tested in concrete material and through the resistance of the material the idea was reformed and developed and then re-tested in material again. In the image below (Image 5), I have sketched out the view of embodied sense-making in design and craft practices that emerges from this research. The model describes the difference in the two modes.

The more conceptual or imaginary activities are shown in the *Representational mode* loop on the left. Activities linked to bodily and concrete manipulation of materials are shown in the *Non-representational mode* loop on the right. The arrow shows how the practitioner is moving between the idea mode and concrete mode in loops, where knowledge is reinforced for each loop and the ideas are tested and re-configured through a concrete re-making and re-knowing.

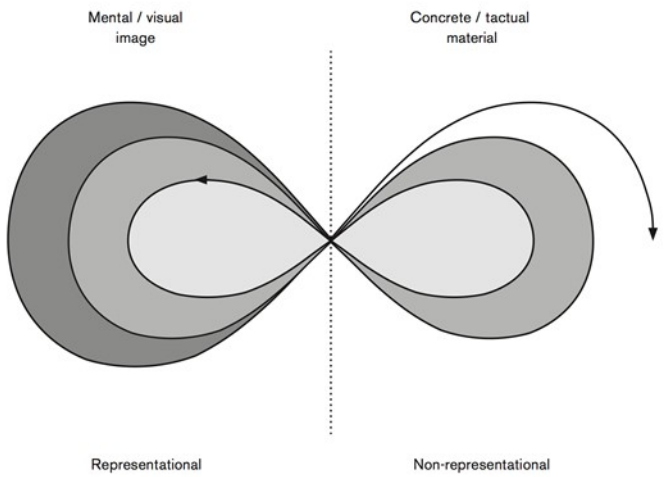


Image 5 Embodied sense-making in design and craft practice[61]

The transition point between these two modes is presented as a narrow passage between the two loops. This proposes that the move from the representational mode into the more concrete non-representational mode may be experienced as abrupt and problematic, particularly for the novice practitioner who might be less experienced with material properties. Similarly, the other way around might be difficult, since the negotiation with the material that goes on in the concrete non-representational mode may sometimes forcefully change the imagined design. On the other hand, the non-representational mode allows for a sense-making process that also includes the voice of the material, the material agency.

The design process is often described as a thinking process that does not involve the manipulation of materials[1] Instead designers work with design representations such as drawings and concepts. The difference in attitude to sense-making in a distant representational mode that is concerned with a more objectifying view of what is visible and on the other hand the more immediate subjective and concrete non-representational mode does

explain the difficulty in the transfer between these modes shown in the model above. In the more concrete mode, the embodied sensory reflection is highlighted and physical constraints are met concretely and physically, allowing "visibilities of the world in the subject's felt engagement with it" [53:646]

However, the grounding of the lived experience into the body, stores it in a way that may be utilized even in qualitatively different new situations. This is a vital knowledge, particularly for designers. The students that participated in my research created mental images of their intended designs in their minds even before starting concrete material testing, but these mental images were very realistic and they were based on previous encounters with materials. Thus, they used their embodied knowledge of materials and their constraints in the formation of the initial image of their artefacts. However, some of the other students participating in this course were not as experienced in handling materials as the two that I studied closer.

One student in particular had difficulty in creating any material implementations of his ideas. The mental images that he created were too far away from what was possible to realize in material, thus he had to constantly reformulate and rethink his designs. In one of our discussions he said that he was not very "good with his hands" and that he dislikes materials. He said that he was not able to do what he wanted but had to do something else instead. I understood his inability to create functioning mental images of his designs to be due to a lack of embodied knowledge of material properties.

Conclusion

The importance of touch and haptic experiences in decision-making processes and the link to emotions in this context was one of the key findings. The practitioner seems to gain not only manual skills during a making process, but she also builds herself as a practitioner. Manipulating material may be seen as a way of being in and affecting the world as well as negotiating meaning related to one's abilities and limitations. The craft practices are safe places to fail, restore and grow one's self even stronger and more skilful.

Another aspect relating to education was the realisation that tactile skills might at times be better taught by tactile means, as the embodied knowledge of the teacher, including exact timing of movements and limb pressure, are more readily available to the student in such a setting. This case shows that even entirely tactile teaching (without sight or hearing) could produce a beneficial learning experience for the person receiving the tactual guidance.

An overarching finding of the whole study was the many different levels and notions of emotions that surfaced in connection to haptic experiences. In addition to being linked to self-esteem and empowerment as in the case of both the deafblind and the student case, emotions were also regulating risk assessment, decision-making and problem-solving in a making process. Emotions aided the maker in applying the right amount of attention and caution in the management of critical incidents. Previous experiences are stored in the body and reactivated reminding the maker of the available opportunities and risks related to a situation. In the meeting of new material properties, similar previous experiences are related to and a form of re-knowing of previous knowing aids in overcoming new challenges. This re-knowing was seen in all three cases but perhaps especially in the design students' processes.

When the design is taken from a 2D drawing to a 3D prototype, there is a change in working modality that involves the materialization and externalization of mental ideas. Embodied and sensory knowledge of material properties is especially useful in this transition from the representation to the concrete and lived experience of the artefact. One of the main research results of my study is precisely that this embodied knowledge of materials and their properties in relation to the skills of the practitioner is what design and craft students and professionals rely on in their practice. Therefore, their body-based knowledge works as an informant also in the conceptual and immaterial phases of the design and planning of future artefacts.

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References:

1 Dormer, P. (1993). What is a designer? In Dormer, P. (Ed.) *Design Since 1945*. London: Thames and Hudson. 9-31.
2 Almevik, G. Jarefjäll, P. & Samuelsson, O. (2013). Tacit record: augmented documentation methods to access traditional blacksmith skills. In Gottlieb, H. (Ed.) *NODEM 2013 Beyond Control – The Collaborative Museum and Its Challenges*. Conference proceedings of the international conference on design and digital Heritage. Stockholm, Sweden.
3 Bang, A. L. (2010). Emotional value of applied textiles: Dialogue-oriented and participatory approaches to textile design. PhD Thesis. Kolding School of Design, Aarhus School of architecture, Denmark.
4 Heimer, A. (2016). The aesthetics of form knowledge: Embodied knowledge through materialization. *Studies in Material Thinking,* 14, article 4.
5 Ings, W. (2014). Embodied drawing: a case study in narrative design. *Artifact 3* (2), 2.1-2.10.
6 Mäkelä, M. (2003). *Saveen piirtyviä muistoja. Subjektiivisen luomisprosessin ja sukupuolen representaatioita* [Memories on clay. Representations of subjective creation process and gender.] Doctoral Thesis. Helsinki: Taideteollinen korkeakoulu.
7 Mäkelä, M. (2016). Personal exploration: Serendipity and intentionality as altering positions in a creative process. *FORMakademisk*. 9 (1), Article 2, 1-12
8 Niedderer, K. (2012). *Exploring elasticity as a medium for emotional expression in silver design*. In Durling, D., Israsena, P., Poldma, T. & Valtonen, A. (Eds.), *Proceedings of the International DRS Conference 2012*. Bangkok, Thailand, 4-7 July 2012.
9 Niedderer, K. (2013). Explorative materiality and knowledge: The role of creative exploration and artefacts in design research. *FORMakademisk*, 6 (2), 1 – 20.

10 Niedderer, K. & Reilly, L. (2010). Research practice in art and design: Experiential knowledge and organized inquiry, *Journal of Research Practice*, 6 (2), Article E2, 1-11.
11 Niedderer, K. & Townsend, K. (2014). Designing craft research: Joining Emotion and Knowledge. *The Design Journal*, 17 (4), 624-684.
12 Nimkulrat, N. (2009). *Paperness: Expressive material in textile art from an artist's viewpoint*. Doctoral Thesis. Helsinki, Finland: University of Art and Design Helsinki.
13 Nimkulrat, N. (2012). Hands-on intellect: Integrating craft practice into design research. *International Journal of Design*, 6(3), 1-14.
14 O'Connor, E. (2005). Embodied knowledge: The experience of meaning and the struggle towards proficiency in glassblowing. *Ethnography*, 6 (2), 183-204.
15 O'Connor, E. (2007). Hot glass: The calorific imagination of practice in glassblowing. In Calhoun, C. and 16 Sennett, R. (Eds.), *Practicing Culture*. London: Routledge
Pedgley, O. (2007). Capturing and analysing own design activity. *Design Studies*, 28 (5). 463–83.
17 Riis, K. (2016). Designkundskabens DNA: Udforskning af designkunskab gennem designprocessen Mit DNA. Doctoral Thesis. Det humanistiske fakultet, Institutt for filosofi og religionsvitenskap NTNU.
18 Tin, M.B. (2013) Making and the sense it makes. Conceptual manifesto simultaneously published in FORMakademisk, Vol 6:2, Studies in Material Thinking, Vol 9, and Techne A Series, Vol 20:2,
https://journals.hioa.no/index.php/formakademisk/article/view/650
19 Thompson, E & Stapleton, M. (2008). Making sense of sense-making. *Topoi*. Retrieved on the 20th of April 2016 from https://evanthompsondotme.files.wordpress.com/2012/11/making-sense-of-sense-making.pdf
20 Gibson, J. J. (1986). *The ecological approach to visual perception*. New York: Psychology Press.
21 Damasio, A. (1994). *Descartes' error: Emotion, reason, and the human mind*. New York. Putnam.
22 Damasio, A. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. New York. Hartcourt.
23 Johnson, M. (2007), *The meaning of the body*. Chicago: Chicago University Press.
24 Noë, A. (2004). *Action in perception*. Cambridge: The MIT press.
25 Noë, A. (2009). *Out of our heads*. New York: Hill and Wang
26 Thompson, E (2010) Mind in Life: Biology, Phenomenology, and the Sciences of Mind Harvard University Press
27 Varela, F.J. & Thompson, E. & Rosch, E. (1991). *The embodied mind: Cognitive science & human experience*. Cambridge: MIT
28 Schön, D. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
29 Schön, D. (1991). Designing as a reflective conversation with the materials of a design situation. Keynote talk. *Edinburgh Conference on Artificial Intelligence in Design*, June 25. Edinburgh. Retrieved on March 3, 2016 from http://www.cs.uml.edu/ecg/pub/uploads/DesignThinking/schon-reflective-conversation-talk-design-games.pdf
30 Sennett, R. (2009). *The Craftsman*. London: Penguin books.
31 Huotilainen, M., Rankanen, M., Groth, C., Seitamaa-Hakkarainen, P. & Mäkelä, M. (in Review). Why our brains love arts and crafts: Implications of creative practices on psychophysical well-being *FORMakademisk Journal*.
32 Andrade, J. (2010). What does doodling do? *Applied Cognitive Psychology*, 24(1), 100–106.
33 Toussaint, L. & Meugnot, A. (2013). Short-term limb immobilization affects cognitive motor processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 39(2), 623.
34 Allen, C. B., Celikel, T., & Feldman, D. E. (2003). Long-term depression induced by sensory deprivation during cortical map plasticity in vivo. *Nature neuroscience*, *6*(3), 291–299.
35 Hari, R & Kujala, M (2009). Brain basis of human social interaction: From concepts to brain imaging. *The American Physiological Society*. 89 (2), 453-479.
36 Kiefer, M., & Trump, M. N. (2012). Embodiment theory and education: The foundations of cognition in perception and action. *Trends in Neuroscience and Education, 1*, 15–20.
37 Lusebrink, V., B. (2004). Art therapy and the brain: An attempt to understand the underlying processes of art expression in therapy. *Art Therapy: Journal of the American Art Therapy Association*. 21(3), 125–135.
38 Lusebrink, V., B. (2010). Assessment and therapeutic application of the expressive therapies continuum: Implications for brain structures and functions. *Art Therapy: Journal of the American Art Therapy Association*. 27(4), 168–177.
39 Borghi AM, Cimatti F. (2010) Embodied cognition and beyond: acting and sensing the body. Neuropsychologia. 2010 Feb; 48(3):763-73.
40 Gallese, V. (2001). The 'Shared Manifold' hypothesis: From mirror neurons to empathy. *Journal of Consciousness Studies*, 8, (5-7), 33-50.
41 Rizzolatti, G., & Craighero, L. (2004). The mirror neuron system. *Annual Review of Neuroscience*, 27, 169–192.
42 Gallese, V. & Lakoff, G. (2005). The brain's concepts: The role of the sensory-motor system in conceptual knowledge. *Cognitive Neuropsychology*, 22 (3/4), 455-479.
Gibson, J. J. (1983). *The senses considered as perceptual systems*. Connecticut: Greenwood press. (Original work 1966).
Rodaway P (1994) Sensuous geographies : body, sense, and place. London ; New York : Routledge,
45 Patterson M (2009) Haptic Geographies: Ethnography, Haptic Knowledges and Sensuous Dispositions
Progress in Human Geography 55 33(6):766-788
46 Pink, S. (2009) *Doing Sensory ethnography*. London: SAGE Publications.
47 Pink, P. (2011) A multisensory approach to visual methods. In Margolis, E & Pauwels, L. (Eds.), *The SAGE Handbook Visual Research Methods*. London: SAGE Publications, 601-615.
48 Ingold, T. (2004) Culture on the ground. *Journal of Material Culture*, 9 (2). 315-340.
49 Mcpherson, H. (2009) Articulating blind touch: Thinking through the feet. Senses and society, 4 (2), 179-194
50 Ingold, T. (2013). *Making: Anthropology, archaeology, art and architecture*. London and New York: Routledge.
51 Anderson, B. & Harrison, P. (2010). The promise of non-representational theories. In Anderson, B., Harrison, P. (Eds.) *Taking-place: non-representational theories and geography*. Farnham: Ashgate. 1-36.
52 Harrison, P (2000). Making sense: Embodiment and the sensibilities of the everyday. *Environment and planning D: Society and space*, 18, 497 - 517
53 Gregory, D., Johnston, RJ., Pratt, G., Watts, M., Whatmore, S. (Eds.) (2009). *The dictionary of human geography* 5th edition. Oxford: Wiley-Blackwell.
54 Van Elk, M., Slors, M., & Bekkering, H. (2010). Embodied Language Comprehension Requires an Enactivist Paradigm of Cognition. *Frontiers in Psychology*, *1*, 234
55 Claxton, G. (2012) Turning thinking on its head: How bodies make up their minds. *Thinking skills and creativity*, *7*, 78-84
56 Lakoff, G. & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.
57 Lakoff, G. & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to Western thought*. New York: Basic Books.
58 Johnson, M. (1987), *The body in the mind*. Chicago: Chicago University Press.
59 Kangas, K. (2014). *The artificial project – Promoting design learning in the elementary classroom*. Doctoral Thesis. Unigrafia, Helsinki.
60 Kosonen, K. & Mäkelä, M. (2012). Designing platform for exploring and reflecting on creative process. *Procedia – Social and Behavioural Sciences*, 45, 227–238.
61 Groth, C. (2017). *Making sense through hands: Design and craft practice analysed as embodied cognition*. Aalto University publication series Doctoral dissertations 1/2017. Aalto Arts books, Helsinki.
62 Nicholas, J. (2010). *From active touch to tactile communication: What's tactile cognition got to do with it?* Aalborg: The Danish Resource Centre on Congenital Deafblindness.
63 Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2013). Making Sense - what can we learn from experts of tactile knowledge? *FORMakademisk Journal*, 6, (2), 1-12
64 Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2015). Tactile augmentation: A multimethod for capturing experiential knowledge. *Craft Research*, Intellect, UK 6, (1), 57-81
65 Groth, C. (2015). Emotions in risk-assessment and decision-making processes during craft practice. *Journal of Research Practice*, 11, (2) article M5
66 Groth, C., Mäkelä, M. (2016). The knowing body in material exploration. *Studies in Material Thinking*, 14, article 02

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https://img.scoop.it/2goc4lFFG8N6dH2YUTj4TIXXXL4j3HpexhjNOf_P3YmryPKwJ94QGRtDb3Sbc6KY