9 Thinking through hands in education

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Making sense and knowledge creation

If all cognition is embodied, the need to talk about embodied cognition as something distinct from any other type of cognition is redundant (Gulliksen, 2017, p. 8). In effect, this means that the division between theoretical and practical subjects is also superficial—for example, mathematics, which is traditionally thought of as abstract and immaterial, can be argued to be deeply grounded in kinesthetic and somatic experiences (Abrahamson & Lindgren, 2014, p. 358). In this chapter, we explore the role of the body in sense-making with and through hands and materials. We look especially at examples in arts and crafts and how embodied learning in these subjects may develop skills and knowledge useful in other domains.

Arts and crafts involve aesthetic learning and making that require bodily interactions with materials, in which the learner needs to make use of the whole sensory spectrum. Learning is thus *embodied* and *situated* in that context. It is *extended* through the interaction with tools, materials, and others, and it is *enacted* through the making of artefacts. The word "aesthetics" refers, amongst other things, to a sensation of the senses and sensory experiences in a more general way, not only connected to appreciation of beauty. In aesthetic learning processes, the learner is sensitised into paying closer attention to notions of sensory experiences and subtle changes, making sensory evaluations, such as judging matters of taste, balance, dimension, shade, consistency, or depth. All of these processes require a close, intimate, and reflective relationship between the learner and their environment (Strati, 2007). Our sensory modalities—such as vision, hearing, and touch—constitute the contact point between the learner and their surroundings. The visual sense has traditionally been given preference, and in many ways, we live in an ocular-centric world (Howes, 2014). However, when interacting with materials, other more proximate senses are just as important. For practitioners of arts and crafts, the haptic system is adamantine, as hands are used for most tasks in the studio. There is also evolutionary evidence explaining the role of hands in the development of the brain (Wilson, 1999). Thus, there are good reasons to pay attention to the role of hands and haptic, tactile, and kinaesthetic experiences, especially in education (Søyland, 2021).

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In the field of professional craft, practitioners think, feel, and make judgements; plan; and theorise *in action* and in direct negotiation with the materials (Malafouris & Koukouti, 2022). Arts and crafts education is the subject in which we can bring this aesthetic form of sense-making through material interaction to pupils in schools. The act of making something in a material may be seen as more than just manipulating materials or forming it into a desired shape: It is, in many ways, a conversation or negotiation between the maker and the material environment (see Figure 9.1) (Brink & Reddy, 2019; Malafouris & Koukouti, 2022). By manipulating material, we affect the environment, but we are also affected by the making experience itself (Groth, 2017). In the Nordic countries, the subject of arts and crafts, or rather "sloyd", has an extended pedagogical agenda of cultivating not only practical content knowledge but also appreciation for work morale, quality, accuracy, cleanliness, and neatness, and for the development of independence, self-reliance, and mental stamina (Salomon et al., 1907).

The craft practitioner's process includes taking risks and, therefore, inevitably also failure. Problems related to materials and techniques emerge and need to be worked through and solved. Teachers guiding craft learners are aware of this and can take this into account when designing assignments, helping pupils to "fail early" in order to help scaffold their creative processes and facilitate their problem-solving and generation of new ideas (Sawyer, 2018, p. 158, p. 164). Through such trial and error, craft practitioners become comfortable taking risks when manipulating materials and learn to utilise "safe failing" as a

Figure 9.1 Child learning how to carve fresh wood with a spokeshave. Photograph by Marte S. Gulliksen.

way to move the process forward. This way, the craft practitioner grows their resilience (Huotilainen et al., 2018).

As we process ideas into artefacts, we also make meanings, and through these artefacts, we share and communicate those meanings. 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 such as drawings, texts, artefacts, performances, songs, plays, or films. In a learning context, artefacts can be seen as epistemic objects that, especially in collaborative learning, carry the process and knowledge created in the group (Knorr-Cetina, 2001). Learning can thus be seen as a process of knowledge *creation* (Paavola & Hakkarainen, 2005) that becomes especially noticeable in materially based subjects such as arts and crafts. The process of handling materials is thus closely linked to handling knowledge: making is thinking through hands (Groth, 2017). In schools, craft practice offers the opportunity to make sense of the world and develop our manual skills, problem-solving abilities, and sense of accomplishment and resilience. Arts and crafts are ideal contexts for concretely "getting in touch" with our environment and the materiality that surrounds us. This makes the subject a premise supplier for other content, such as STEAM and invention pedagogy (Korhonen et al., 2022) and environmental sustainability (Fredriksen & Groth, 2022).

Sense-making and the role of action in cognition

This chapter is called "Thinking through Hands in Education"; however, the concept of sense-making is more precise, and we will use it to explain this notion more closely. The meaning of *sense-making* is connected to utilising our senses in the act of making meaning. Sense-making is a key concept in enactivist philosophy, a branch of embodied cognition theory that emphasises the organism-environment coupling, and in which the body is seen as a vehicle in all learning (Newen et al., 2018; Noë, 2004). Enactivist thinking suggests that a person learns through action and accumulates knowledge through their embodied experiences with their environment (Noë, 2004; Varela et al., 1991). The brain's plasticity enhances its 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 at anticipating and predicting possible outcomes from future similar actions and interactions. For example, material properties may at first be experienced as providing resistance before the novice learns how to predict the material's behaviour and how to overcome difficulties in manipulating them. Hands-on guidance can help in learning the exact amount of pressure and timing of movements (see Figure 9.2).

Craft practice requires activation of the body, from full-body interaction, such as sawing and hammering, to fine motor tasks, such as stitching and drawing. A neuroscientific reason for activating our bodies during learning is the fact that moving our bodies activates our brains (Huotilainen et al., 2018). Making small drawings or being active in other ways—for example, by

Figure 9.2 Child throwing clay for the first time aided by hands-on guidance. Photograph by Camilla Groth.

handling material or knitting while listening to a lecture can yield better learning results than just passively listening (Andrade, 2010; Huotilainen et al., 2018). Touching and forming materials, such as typically happens in craft activities, stimulates certain areas of the brain. Physically manipulating and exploring new materials are crucial for healthy brain development (Kiefer & Trumpp, 2012; Lusebrink, 2004).

Learning through material engagement

The notions of experiential learning and of learning by hands-on doing and reflecting on the experiences were initially developed by Dewey (1938).

Through their concrete and material nature, arts and crafts practices offer ample physical opportunities for familiarising with different material properties. During a process of learning and reflecting in and through action (Schön, 1983) and in the predictions of a material's behaviour, the abilities and limitations of one's own bodily strength and capacity are noticed in a new way (Groth et al., 2013). By experimenting to overcome material resistance, students practise problem-solving and can test creative solutions by applying existing knowledge to new contexts. In the next section, we explain this more specifically through examples from previous research.

Examples from arts and crafts education

We briefly present examples of craft education in, primary school education, and higher education to exemplify embodied learning aspects discussed later.

Example 1

In primary education in Finland, craft teacher education recently included multi-materiality as a strategy, moving away from gendered aspects of material-based craft teacher education in either hard (wood, metal) or soft (textile) materials. The craft subject thus facilitates new materials in technology education, in which one strategy is to engage pupils in STEAM subjects through maker-centred learning.

In this example, a group of primary school pupils aged 10–12 are solving a problem regarding their lamp design project (the original study is described in full in Kangas et al., 2013). The pupils have difficulty imagining the height of the lamp over the table: It should ideally hang in a way that no one can hit their head while still allowing enough light onto the table. They build on each other's ideas, using gestures and drawing for communication, and externalise their ideas in visual representations that help them discuss and reflect on the design task collaboratively. As imagination is no longer enough to solve problems on an idea level, prototypes are built, and the physical constraints are made more concrete. The pupils then solve the problem of the hanging lamp by physically standing up on the table and pointing a telescopic pointer down onto the table, thus using both their own bodies and authentic and situated material scaffolds in their problem-solving task. That they collaborate and work on the task together forces them to externalise their thinking through verbalisation and sketching—thus also making the issues articulated rather than tacit hunches. When sharing the problem space with others, cognition is offloaded into the social space, and the problem can be approached from the multiple perspectives represented by each pupil's experiential knowledge.

Example 2

In this example from higher education in design in Finland, the task was to create an artefact for an exhibition as a result of a conceptual artistic process (this case study is described in full in Groth & Mäkelä, 2016). The students created designs in their minds before starting concrete material testing. In a few of the students' cases, these plans were very realistic, and based on previous encounters with materials, they used their embodied knowledge of materials and their constraints in the formation of the initial mental image of their artefacts. The students then externalised their ideas through visual representations and models, and here the students' abilities to make realistic plans for their designs differed to a large degree.

One student used her previous knowledge of materials and their behaviour when encountering new, unfamiliar materials that—to her—behaved unpredictably. She also made use of external aids in the form of scaffolding structures to facilitate her understanding of the construction she needed to make, transferring her 2D idea into a 3D shape. She said that the task could not have been solved solely by thinking but required the whole body in the learning process. However, some other students were not as experienced in handling materials. One student in particular had difficulty creating any material implementations from his ideas. The plans he created were too complicated to be realised in material; he had to constantly reformulate and rethink his designs, but nothing seemed to work in the physical realm. He reflected on this inability to create functioning designs as a lack of experiential knowledge of material properties.

As the students experienced new materials in their exploration process, the new and unfamiliar material behaviour disrupted their workflows and made them question their skills and their identities as makers. The students' anxieties were soon overcome by resorting to familiar patterns and methods of solving material problems known to them from other, more familiar domains. One student listed his many different past skill-learning experiences and called these his "mental toolbox". While all those skills—such as painting, martial arts, diving, and piano playing—were very bodily skills, he still thought of these as "mental" in the way they are carried with him into new situations and constitute part of who he is as a person.

The usefulness of embodied teaching and learning in other school subjects

The domain of arts and crafts education allows for a safe failing and learning environment for gaining experiential knowledge about material properties and

general physical constraints. The concrete materiality in arts and crafts practice offers opportunities to practise overcoming material resistances and grow confidence, and to train in creative problem-solving and making scaffolds as aids for both cognitive and physical constraints.

Embodied teaching and learning highlight the use of situated, contextual, and real-life problem-solving in which learners work on authentic, project-based, and open-ended learning tasks. Material artefacts such as prototypes carry epistemic processes that are modified and iterated through collaboration with others. Material prototypes scaffold learning and help make concrete the problem-solving process, allowing for metacognitive reflections on the learning. Additionally, artefacts carry meaning in another form than the textual or auditory modalities and also tacit and multimodal aspects of understanding. All these forms of learning extend cognition and the learning activity out into the learning environment and make it visible.

Training the ability to find strategies for scaffolding one's own process is relevant in the arts and crafts but is equally important in—for example—mathematics, science subjects in laboratory settings, and reading and writing. External aids are also used in mathematics and physics, which are generally seen as theoretical subjects. On the contrary, there are many examples of extended cognition in mathematics, such as counting by using fingers or an abacus to offload cognitive tasks into the environment (Abrahamson & Lindgren, 2014, p. 362). The ability to create external aids as a habit and strategy for creative problem-solving and externalising thinking can be trained in arts and crafts—for example, through drawing and model-making.

Studio pedagogy in arts and crafts incorporates most embodied learning strategies naturally (Sawyer, 2018). Apprentice learning involves situated and sustained scaffolding that first follows the student closely with real-time guiding and hands-on showing and telling (Groth et al., 2013). Such methods scaffold learning and offer a distributed sense-making process through cognitive apprenticeship (Collins & Kapur, 2014). As the student gets more familiar with the practice, appropriate "fading" of the support gives the student more responsibility for their learning while still having aid close by. Many of these strategies can be applied in other school subjects.

Recommendations for education

Finally, we encourage teachers to consider how they can encourage learners' embodied learning in the following ways:

Understanding abstract concepts

Embodied sense-making is especially useful in the transition from abstract concepts to lived experience through material mediation in the form of prototypes. It is similarly useful the other way around: from the lived experience to the abstract representation. As this skill is a higher-order cognitive activity

fuelled by material interaction, it is also useful in other contexts. For example, when a student in mathematics constructs a pyramid with a pen on a piece of paper, they need to conceptualise the abstract idea "pyramid" as a prospective 3D form in a virtual space and find ways to represent this on a 2D paper. They can thus draw on previous experiences of a physical 3D pyramid to scaffold their understanding of this abstract form.

External aids

Teachers can consciously support students' use of external aids to negate mental overload. Such techniques also help concretise the topic being learned and provide training to create and test learning aids. Active scaffolding is a sign of constructive and creative approaches to problem-solving and opens learners up to thinking outside the box. Material manipulation in or outside of craft practices also aids abstract thinking, as material experiences can scaffold abstract spatial thinking. For example, if the student thinks of a pyramid and needs to imagine how it would look from the side, this is a mental rotation task that can be facilitated by making a mock-up pyramid in 3D that is rotated physically. Social interaction, collaboration, and sharing tasks with other learners are ways of extending and amplifying thinking within the group.

Trial and error

Teachers can facilitate opportunities for trial and error and emphasise the value of experiential learning through making. Providing such situations, learners could build themselves as knowledge-makers and gain self-esteem and a sense of ability and agency relating to their material environment. By engaging in processes that provide material and mental resistance, teachers would also help students learn endurance and perseverance. Additionally, students may be encouraged to experiment in novel ways and in new areas, building innovative strategies for learning and engaging with problems.

Safe failing

Providing learners with a safe and accepting environment that allows them to practise trial and error is important. Failing in material manipulation tasks is safe: Nothing bad can happen; the process can easily be restored, and the learner can grow even stronger and more skilful through overcoming resistance in the process (Huotilainen et al., 2018). Such skill in how to allow oneself to fail safely to learn quicker can be useful in other contexts as well. Previous experience in safe failing could mediate disappointment when meeting new topics and subjects one may be unsure of mastering. For the teacher, this entails finding strategies that allow for individual adjustments and multiple approaches to scaffold safe failing through supportive guidance.

Endurance and perseverance

Manufacturing something well in a material is time-consuming and offers slow but lasting rewards, as opposed to quick and multiple rewards (such as, for example, in gaming). Thus, material making develops perseverance and self-control as well as the ability to wait for rewards. Striving for quality and doing a good job—for the feeling of personal achievement rather than for external rewards—may also teach a sense of work ethic and purpose in life.

Conclusion

In this chapter, we have discussed the role of the body in sense-making through craft practices while highlighting the hands as a connecting point between the learner and the world. We have discussed craft practices as processes of making knowledge and how overcoming material resistance can help build resilience and self-reliance. Key features of learning through material engagements include the importance of gaining experiential knowledge of materials and their properties, and the benefits of being able to scaffold and concretise learning and self-making. On a societal level, different kinds and qualities of making occur in multiple forms, on many levels, and in different contexts. By transforming matter, we transform ourselves and, by extension, society little by little (Groth et al., 2022). Arts and crafts thus work as a premise supplier for other study subjects in which learners may test and engage with content knowledge in multimodal embodied and reflective ways. The relevance of the arts and crafts subject to other domains of life and study is its role as a facilitator of subject content while providing tools for both embodied learning and reflection—a way to connect oneself with the world.

References

Abrahamson, D., & Lindgren, R. (2014). Embodiment and embodied design. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 358–76). Cambridge University Press.

Andrade, J. (2010). What does doodling do? *Applied Cognitive Psychology*, *24*(1), 100–6.

Brink, I., & Reddy, V. (2019). Dialogue in the making: Emotional engagement with materials. *Phenomenology and the Cognitive Sciences*, *19*, 23–45.

Collins, A., & Kapur, M. (2014). Cognitive apprenticeship. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 109–27). Cambridge University Press.

Dewey, J. (1938). *Experience and education*. Simon and Schuster.

Fredriksen, B. C., & Groth, C. (2022). *Expanding environmental awareness in education through the arts: Crafting-with the environment*. Springer Nature.

Groth, C. (2017). *Making sense through hands: Design and craft practice analysed as embodied cognition* [Doctoral dissertation, Aalto University]. Aalto ARTS Books.

Groth, C., & Mäkelä, M. (2016). The knowing body in material exploration. *Studies in Material Thinking*, *14*, Article 02.

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.
Groth, C., Townsend, K., Westerlund, T., & Almevik, G. (Eds.). (2022). Craft is ubiquitous. Editorial. *Craft Research*, *special issue on craft sciences*, *13*(2), 211–20.
Gulliksen, M. S. (2017). Making matters? Unpacking the role of practical aesthetic making activities in the general education through the theoretical lens of embodied learning. *Cogent Education*, *4*(1), Article 1415108.
Howes, D. (Ed.). (2014). *A cultural history of the senses in the modern age: 1920–2000.* Bloomsbury.
Huotilainen, M., Rankanen, M., Groth, C., Seitamaa-Hakkarainen, P., & Mäkelä, M. (2018). Why our brains love arts and crafts. *Form Akademisk*, *11*(2), 1–18.
Kangas, K., Seitamaa-Hakkarainen, P., & Hakkarainen, K. (2013). Design thinking in elementary students' collaborative lamp designing process. *Design and Technology Education: An International Journal*, *18*(1), 30–43.
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.
Knorr-Cetina, K. D. (2001). Objectual practice. In T. R. K. C. Schatzki & E. Von Savigny, (Eds.), *The practice turn in contemporary theory* (pp. 175–88). Routledge.
Korhonen, T., Kangas, K., & Salo, L. (2022). *Invention pedagogy—The Finnish approach to maker education*. Routledge.
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), 125–35.
Malafouris, L., & Koukouti, M. D. (2022). Where the touching is touched: The role of haptic attentive unity in the dialogue between maker and material. *Multimodality & Society*, *2*(3), 265–87.
Newen, A., Gallagher, S., & de Bruin, L. (2018). Introduction: 4E cognition: Historical roots, key concepts, and central issues. In *The Oxford handbook of 4E cognition* (pp. 3–8). Oxford University Press.
Noë, A. (2004). *Action in perception*. MIT Press.
Paavola, S., & Hakkarainen, K. (2005). The knowledge creation metaphor – An emergent epistemological approach to learning. *Science & Education*, *14*, 535–57.
Salomon, O., Nordendahl, C., & Johansson, A. (1907). *The teachers handbook of Slöjd* (3rd ed.). Silver, Burdett et Co. Publishers. https://archive.org/details/teachersbookofsl00saloiala/page/n5/mode/2up?view=theater
Sawyer, R. K. (2018). Teaching and learning how to create in schools of art and design. *Journal of the Learning Sciences*, *27*(1), 137–81.
Schön, D. (1983). *The reflective practitioner: How professionals think in action*. Basic Books.
Søyland, L. (2021). *Grasping materialities: Making sense through explorative touch interactions with materials and digital technologies* [Doctoral dissertation, University of South Eastern Norway].
Strati, A. (2007). Sensible knowledge and practice-based learning. *Management Learning*, *38*(1), 61–77.
Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind: Cognitive science and human experience*. MIT Press.
Wilson, F. R. (1999). *The Hand: How its use shapes the brain, language and human culture*. Vintage books.