Crafts and learning – as seen through Embodied cognition

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This article aims to provide insight in the research area of embodied cognition and shows how it can emphasize how we understand the skills taught in sloyd education and thus create new arguments for the didactic relevance of sloyd. This is relevant since the practical competence in the Danish public school has diminished over the past 20 years, on behalf of an increasingly theoretical public school. We need strong scientific arguments for the maintenance and further development of craft as a school subject. The article is a theoretical contribution without practitioner empirical parts, and the method used is a review of embodied cognition research, put in perspective to the author´s experience with sloyd education and general woodworking. As such, it should be read as an essay. Embodied cognition differs from traditional brain research, in the understanding that the brain is plastic: cognition is shaped by the brain being embodied in our body, embedded in our surroundings, extended through tools, and enactive through the necessity of human movement. The fundamental structures of wood and tools are highly functionally coded. Therefore, techniques and working methods in sloyd are taught, learned, and stored through repetitive practice and training, corresponding to the design of the tools and materials. At the same time, the way our brain governs our actions with the tools, is highly dependent on the surroundings in which we learn. The background and prerequisites for embodied cognition as a research field are pointed out, explaining why the neurological hierarchy of amodal thinking demands that tools and techniques in sloyd must be gradually introduced and learned, so the pupils can use them in the best conceivable way in a free, creative design processes. Simultaneously, our modal perceptual impulses in the neural network are inextricably connected to our body's earlier experiences. This perspective review shows that hierarchy of amodal and modal learning processes in sloyd is extremely dependent one another. Therefore, the teacher must take into consideration that every time we introduce a tool or technique to a student or pupil, we consider, and take notice of, the impact of the corporeal learning environment. Further research in the field of sloyd, as seen through embodied cognition, can contribute to understand the importance and necessity of a thorough and precise introduction of tools and materials to pupils in the public school.

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Introduction

The purpose of sloyd (craft and design) in the Danish elementary school, is to teach innovative thinking and design techniques, through the manufacturing of products (UVM, 2018, 2020). To do that, skills must be developed to obtain the necessary control of techniques to create the artifacts that materialize the pupils´ or students´ design ideas. However, the level of practical competence and craft skills in the Danish public school and teacher education, has decreased over the last 20 years (Aisinger, 2017, 2018, 2019a, 2019b). Two separate subjects, wood- and textile sloyd of 60 ECTS each, was shut down in the teacher's education in 2006, and was replaced by the new subject "craft and design" with only 35 ECTS in total (Andersen, Illum, & Hansen, 2018). A subject that is struggling to find its new identity between a theoretical and practical approach to the curriculum (Andersen, 2020; EVA, 2019; Johansen, 2021).

The argument for the trade of sloyd in favor of a more theoretical school and more language and math lessons, was part of a globalization strategy (Regeringen, 2006). Denmark was criticized for being the only Nordic country to close several master's programs in practical/musical subjects, including sloyd. Programs that were needed for developing forthcoming new didactics (Bamford & Qvortrup, 2006). One can argue that this period has been a movement against the relevance of craft in education. With fewer ECTS in teacher education, and the gap between theory and practice in the school subject, sloyd has suffered to a blossoming of Cartesian dualism. This could relate to the eagerness of meeting the 21´st century skills of design, innovation and entrepreneurship (Berthelsen, 2016). Meanwhile, in the late 1990´s, the field of embodied cognition develops fundamental critiques to Cartesian dualistic ontology, internalism, the computationalist approach to cognition, classical cognitivism and mental reductionism (Agostini & Francesconi, 2021, p. 417; Castro-Alonso, Ayres, Zhang, de Koning, & Paas, 2024; Shapiro & Stolz, 2018). A field of research emphasizes the importance of knowing how we learn *with* and *through* our body, and how being in a bodily environment influences our cognitive learning. With the Act on Practical Competence in 2018 (UVM, 2018), the Danish government has targeted that we must strengthen crafts in primary school, and hopefully we´ll see a strengthening of practical teaching in the years to come. The paradox is that while our skill level declines in a school that wants to develop creatively thinking children, research from grounded and embodied cognition works with the hypothesis that when we train and strengthen the motor cortex through movement, drawing and craft tasks, the higher cognitive layers where creativity lies are simultaneously developed (Matheson & Kenett, 2020).This article will focus on how embodied cognition contributes with a broad perspective for bodily learning, insights valuable for understanding the pedagogical context of craft/sloyd. As teachers, we are responsible for the instruction of tools and their use in each material. This is usually learned and taught through context-independent amodal general structures, as a rational cognitive learning method. What we have less control over is that learning instructions and use of tools is filtered through the student's sensory body, and the surroundings in which the student is situated. This is where knowledge about embodied cognition can help us better understand the complexity of workshop teaching.

My own path, and background as a sloyd educator, started with numerous woodcarvings as a child. Later I was taught woodworking sloyd in the public Danish school in the 1980´s. I produced a lot of items, of which several are still functional today. For example, a wooden desk for my mother, and an Inuit kayaker. Products that gave rise to a lot of new ideas and possibilities in working with wood, and which demanded at high level of concentration and skill acquisition. I took my teacher training with a major in sloyd woodworking in 2001, a Pedagogical Diploma education in sloyd shortly after, and took a break from teaching in 2009 to become a trained cabinetmaker. In 2020 I graduated from the university with a degree in didactics – materiel culture. This journey has had one aim, to develop and understand the underlying principles of woodworking, and it´s relevance for pedagogical education. As we acquire craft skills, familiarity with the body enhances, and this will encourage a gradually more free and individual interpretation of the tools and their applications. This creates an equal weighting and a natural taxonomy between craftsmanship and design processes, for the benefit of teaching crafts, innovation and design in the school subject sloyd. A rich skillset can gradually elevate the student to rise above the limitations of the rigidness of wood and tools. To align the minds ideas with the outcome of a design, a teacher must combine the training of skills with the attention to our sensoric surroundings. They are both parts of the beauty and the complex simplicity of sloyd.

How to read the article, and the method used.

In form of an essay, I intend to examine the difference between very basic tool teaching in crafts, and the impressions and impulses that meet the learning child. The goal is twofold: First, to point out the relevance of introducing the individual tools and their use in a simple, taxonomically meaningful way, and continually maintain this attention with the student. Second, to emphasize how our surroundings and body influence what we learn and teach. The first part explains embodied cognition as a concept, and how it relates to the ever changing and developing field of pedagogical neuroscience. To mark a frame for master teaching learning theory, I´ve used Dreyfus' model of skill acquisition. The second part describes important theoretical ideas from embodied cognition: E.g. The Four E´s, Change of Body State, The Neural Correlate, Pattern Recognition and Change of Body State, and weave them together with their relevance to sloyd education. Most of the theoretical contributions in the article are selected based on a university curriculum at DPU, where I studied a master's degree in didactics, material culture in 2018-20. I participated in an elective course on Embodied Cognition under Professor, PhD. Theresa Schilhab. We worked with research in the field by writing and commenting on blog posts for the other participants in the course, where we analyzed research papers based on our own primary interests and expertise. This course gave me so much in-depth knowledge on the complexity of the cognitive body that it enriched my teaching and inspired me to write this conceptual article. As a trained craft teacher and furniture maker, it made sense for me to investigate how this bodily scientific approach could help illuminate some of the issues I had experienced through my own teaching of students and the fascination with the procedural experiences of working with wood. The research articles, together with my personal experiences with teaching, constitute the conceptual basis of this article, and are selected based on the criterion of showing how broad a research foundation the field of Embodied Cognition rests on. How many parts of our cognitive understanding it inflicts. Thus, the article attempts to highlight points that correlate to the impressions that can meet a child in learning situations in indoor and outdoor workshop environments. In this way, the article attempts to draw attention to some fundamental premises that a teacher should consider when continuously planning and evaluating teaching.

There is a difference between how we experience the world and how the world is presented to us. This can be divided into modal-specific representations, which are the direct impact of how the world meets us through our response to nature and surroundings, and (a-)modal general representations, which are more unspecific parts of semantic networks, schemata, and parts that can be seen as fragmented of a whole (Kaup et al., 2024). Knowledge of both representations is important to understand the complexity that meets the learning child in a teaching world that combines rules with degrees of freedom and learning responsibility. Therefore, the individual sections of the article should be read as a presentation of theoretical ideas from the field of embodied cognition, presented with a view to their relevance to craft education. In addition, this perspective may be relevant for teaching in STEM (Science, engineering, technology and math), and other innovative science learning environments, as these correlates to practice- and problem-based forms of teaching who reach out to embodied cognition (Kolovou, 2022; Roberts, Williams, Hodgdon, Payne, & Emanuelli, 2024; Weisberg & Newcombe, 2017).

Grounded- and embodied cognition.

Grounded cognition, and the independent research area of *embodied cognition*, is a term for all the newer theories that emphasize situated and bodily cognition (Schilhab, 2014; Barsalou, 2010; Stolz, 2019). This includes educational neuroscience, an area where traditional neuroscience, brain research, works together with research from pedagogy and psychology (Steffensen and Ejersbo, 2014). The field involves finding connections for how we think and read at a higher level, depending on whether we read a printed or electronic media, and how tactile activities affect other of our higher cognitive functions, such as speaking, remembering and developing creativity. Social neuroscience contributes to find out how social behavior conditions the development of biological mechanisms, by studying neural networks, synaptic connections in the brain, as well as behaviors in hormones, cells and genes (Barsalou, 2010, p. 721). Embodied cognition tries to grapple with the bodily twist by showing the complexity of the "body's brain", i.e. the fact that you cannot reduce the body's learning to neurological scans of the cortex, but that the body, and the way it interacts with the world, has some inherent, unconscious, biologically sensing learning processes that are conditioned by where, and in what context, we´re in. Embodied and grounded cognition examine the same thing, but grounded cognition covers several approaches (Barsalou, 2010). When we use tools, or practice other motor activities, we stimulate the motor cortex system. Neurocognitive research tends to overlook the role of the motor cortex in creative thinking, when establishing models for how humans generate creative thoughts (Matheson & Kenett, 2020). The motor system defines and regulate our ability to execute actions, and grounded- and embodied cognition works with the hypothesis that the motor system is deeply embedded in our ability to generate cognitive- and motor creativity (Matheson & Kenett, 2020; Vasilopoulos & Dumontheil, 2024).

The plastic brain

Over the past 20 years, there´s been a growing interest in investigating how our bodies and the environments we move around in, influence our cognitive learning (Castro-Alonso et al., 2024; Kaup et al., 2024). During this period in neuroscience, even the most neurocentric researchers have gradually begun to accept that the field must open to the plastic brain (Larsen, 2004; Steffensen and Ejersbo, 2014; Stolz, 2019). But what does it mean that the brain is plastic? The brain changes every single day throughout life, not least as a result of experiences and experience (Mogensen, 2013). But what exactly is it that causes it to change? Research's previous separation of the Descartesian dualistic tradition of body and spirit is now brought together in an epigenetic paradigm that recognizes that the human genome can be affected by sociocultural influences. The question is therefore no longer whether biology and culture play together, but how they interact (Steffensen and Ejersbo, 2014).

Associate Professor Steen Nepper Larsen from the Danish University of Pedagogy, DPU describes a tension in brain research between the two perceptions; that we are either governed by biological practices or sociological practices (Larsen, 2014). That is, whether we are subject to the brain's biologically determined limitations, or do we evolve evolutionarily, through socialization. These approaches cannot, he believes, exist separately. Neither biology nor sociology can have a monopoly on how the brain can be defined to fit their certain field of expertise. And it is, a very unclear concept of what plasticity and limitation means. Overall, brain plasticity refers to its ability to respond to external stimuli and information by activating neurons and neural networks, thereby being adaptable to damage and development. But Larsen emphasizes that depending on whether one defines the limits of the brain as psychological, sociocultural, normative, epistemological, or scientific, the answers will, all other things being equal, have different ontological starting points. Steen Nepper Larsen calls it an exciting epoch, where researchers slowly accept and open their eyes to the fact that the brain is conditioned by how we live our lives. He refers to the German philosopher and psychiatrist Thomas Fuchs, who places the brain as a mediator between the body and the environment, and a mediator between other people and our self. The brain *itself*, Fuchs says, "can do nothing, and does nothing" (Larsen, 2014, p. 37).

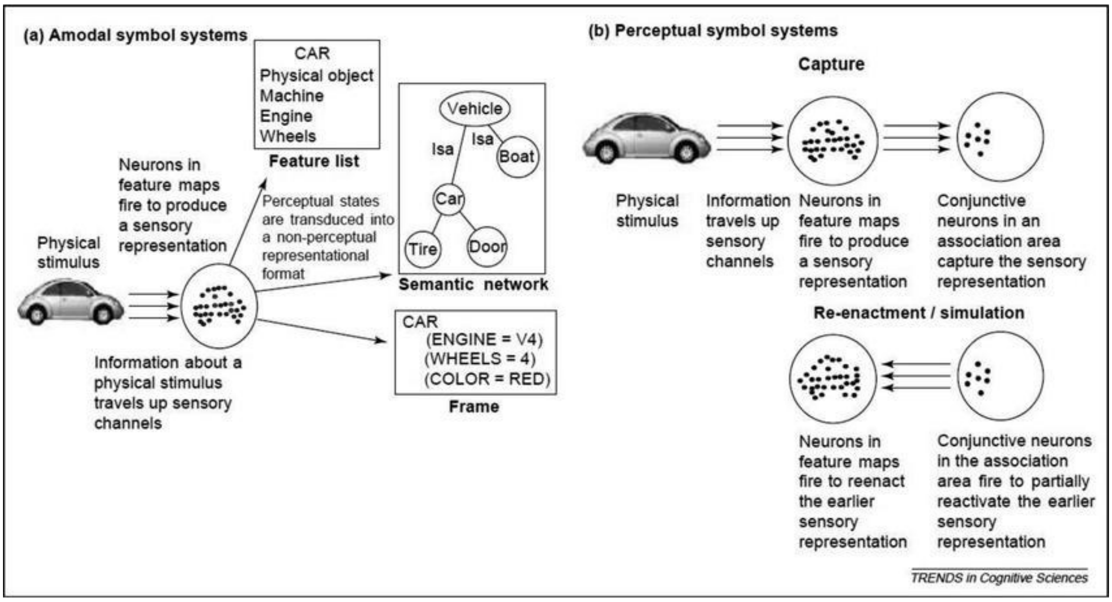
Modal vs. amodal

> "The assumption that the individual parts of the brain are specialized for individual functions has been prevalent throughout most of the history of brain research" (Mogensen, 2013, p. 37).

These assumptions are well documented through scans of experiments with cognitive tasks that have shown results in the same areas of the brain. At the same time, studies of late-acquired brain injuries show that the same damaged areas in patients cause the same cognitive function problems (Mogensen, 2013, p. 38). Similarly, Barsalou, Simmons, Barbey, and Wilson (2003 p. 84) argue, that most current theories in cognitive research do not acknowledge that what is stored in our body through sensory modalities, represents knowledge. However, the redescriptions of states in modality-specific systems for perception, in amodal representational languages do. Central to the idea that concepts are embodied is the description of such concepts as *modal*. This label is intended to emphasize the anti-computationalism that proponents of embodied concepts approve. Symbols in a computer—strings of 1s and 0s—are *amodal*, in the sense that their relationship to their contents is arbitrary. Words too are amodal symbols. The symbol 'lake' means *lake*, but not in virtue of any resemblance or nomological connection it bears towards lakes. There is no reason that 'lake', or any other symbol, should mean *lake*. Other languages than English have other words for *lake* (Shapiro & Stolz, 2018). Grounded cognition as a research area deals with situated and non-conscious cognition (Schilhab, 2013). Central to these theories is our sensory influence from the surroundings, which can be described as modal structures, as the following illustration shows in an uncomplicated way (Barsalou et. al. 2013).

Figure 1.

Amodal vs. modal. (Image taken from Barsalou, Simmons, Barbey & Wilson, 2003)



There is a difference between modal and amodal approaches to knowledge. (Fig. 1.) In amodal processing, neural networks are established that can process the perceived sensory representation. For example, being introduced to a car, through image, sound or words; simultaneously, the representations are passed on to an amodal system that transforms the impression into semantic schemas. It is this information that we use cognitively to speak, remember, or think. Modal systems in the brain respond directly to perception. In addition to information being translated into amodal signs, the sight of a car activates the neurons that associate sensory. That is, on similar impressions or experiences. Later, when you lack the sensory representation of a car, the brain will recreate that feeling, or what you associated with, on the first impression of the car. Both systems assist the cognitive level of memory, language, and thought (Barsalou et al, 2003). The cognitive functions are thus our ability to translate the perceived, the registered or sensed, into speech, memory, or activity. The brain is, of course, important for us to be able to think, and be motoric- and socially active, but it cannot stand alone. And this is where the field begins to expand, because what stimuli can, and should we attribute to our brain's function? Before I dive into these theories about stimuli, I´ll present some taxonomic approaches to educational sloyd.

Modal / amodal approach to sloyd.

Otto Salomon (1849–1907), the founder of the pedagogical Swedish sloyd, referred to sloyd as a learning process that through practice in the short term, was to teach the individual to process a given material, with a given tool, with a given intention (Illum, 2004, p. 27). The craftsman and educator Aksel Mikkelsen (1849–1929) gave these ideas an original Danish expression when he created Danish Skolesløjd in 1882–1886. He realized Pestalozzi's idea of a complete dissolution of practical work into its simplest components as a prerequisite for a pedagogical organization." (Rørby, 1998, p. 4) This describes a pedagogical system that was adapted to school children as new recipients of a complex subject. To break a complex process into its smallest components can be compared to training computational thinking in a pedagogically relevant context. Computational thinking is one of the four areas of competence in the integrated subject Technology Understanding in the Danish primary school (CFU, 2025). All mental symbols, from the perspective of computational cognitive science, are amodal (Shapiro & Spaulding, 2025) and amodal theories are formalizable, and can be implemented in computer hardware (Machery, 2016). In this sense, sloyd can be a great contribution to modern learning requirements. To understand crafts as a tool for designing and committing to a creative process, one can therefore perceive exercises as a series of amodal sub-processes that support the student in creatively translating ideas into action through the processing of materials. Amodal processes play an important role in our ability to generalize and transfer knowledge across different contexts. They are also central to theories of semantic memory and conceptual knowledge, where information is stored and retrieved in a way that is not tied to specific sensory experiences (Kaup et al., 2024). When the student practices techniques and technical terms in woodworking, and thus links the amodal representations specifically to bodily modal experiences, practicing comes to play an important role in learning and creativity by enabling abstract thinking and generalization of knowledge across different contexts. Many of the technical terms the students must learn in sloyd are general-specific representations that doesn´t link an object to an action: A knife has an edge, a bevel angle, a handle, and consists of iron and steel welded together. To execute a task with a minimum of resistance, and a maximum of success, a knife must be handled correct and kept sharpened and well honed. The words, as I just wrote them here, are amodal representations, that you might og might not connect to your own modal representation and bodily experience, given the experience you´ve had with working with a knife. And if I write "Mora 120", it only makes sense to some. This is where the connection between amodal and modal processes comes into play. The individual operations in woodworking are amodal: you need to know if the teeth on the saw are sharp. You can delve into the structure of wood, but the structure itself does not care about a design and cannot tell much about the atmosphere in the forest or give the finished impression of a piece of furniture. It´s information that can stand alone, independent of context. In this understanding, every little input from a tool or material is amodal. Here it is relevant to point out that one cannot see abstract amodal and concrete modal perceptions as a dichotomy. They should be seen as two sides of a continuum where the abstract contributes to our perception of being able to imagine something concrete that contains many expressions and sensibilities (Kaup et al., 2024). This can be transferred to Salomon and Mikkelsen's idea of the student's ability to be in the process of producing products with finish and function from an idea or an instruction, and how tools that do nothing in themselves can contribute to this task.

Dreyfus model of skill acquisition

Following these arguments from neuroscience about the cognitive consequences of our being in the world, I find it relevant to supplement with a description of the Dreyfus brothers' theory of skill acquisition. In one sense you can look at it as a movement from amodal to modal perception. Hubert and Stuart Dreyfus (Dreyfus, 2002; Dreyfus & Dreyfus, 1991) operate with five steps in the human learning process, where you improve your skills through gradually achieved learning and coping steps:

1: Novice, 2: Advanced beginner, 3: Competent practitioner 4: Knowledgeable practitioner 5: Expert.

The body, Dreyfus says, learns through the gradual learning of techniques. The child or new learner starts at a basic context-independent level, where all individual elements have equal relevance. Practice and repetition are important steps, as movements and routines must be embedded in the body's biomechanical structures. By practicing knowledge of patterns and similarities, you work your way up to a more context-dependent level. Later, through experience, you can prioritize and distinguish appropriately between workflows. Gradually, experiences, surroundings, mistakes, repetitions, and practice are developed into an intuitive experiment, which can consider both known and unknown factors and lead a knowledgeable practitioner towards the level of expertise. You can now take different perspectives on a situation. The sloyd beginner, who is our starting point as teachers, learns names, rules, and basic facts, at a completely context-independent level, and therefore cannot adjust his or her own tool handling in relation to the material. The given task is often too complex for this. According to Dreyfus' studies, the ability to speak and hear decreases as the amount of information and rules increases. Rules are thus important for learning something new, but they quickly become a limitation for the learning process (Flyvbjerg, 1998, p. 25). Therefore, you should not rush too quickly but give the students plenty of time to get to know the individual tools and their applications. But it requires didactic and craftsmanship surplus on the part of the teacher, who, in Aristotle's words, is supposed to be an epistemôn. Someone who can master the details of the subject deductively, can move freely and safely in the material, and communicate it systematically with an overview of the whole (Eikeland, 2006). The basic knowledge of crafts in connection with the subject of sloyd/craft and design, is often used too superficial in relation to the decision-making in the design process, with few prior requirements for learning the relevant techniques (Johansen, 2021). This can create a pressure on the student's top-down learning, which means that the work is left unfinished and incomplete. The idea behind school crafts can benefit from the Dreyfus Brothers' model as a gradual taxonomic apprenticeship, and principles from Mikkelsens dissolution of practical work into its simplest components, into manageable amodal parts that children can understand and work from.

The bodily turn ... 4 E's.

In Embodied cognition, the four E' s are spoken of as a prerequisite for the biological learning body. It is a central and fundamental assumption within the bodily cognitive approach, that you move your thinking to physical surroundings and objects, through your body. (Schilhab, 2020). First, we are *embodied*. We are embodied in the body. We can't move, or do anything, without being in our body. It should be if you transcend mentally, or free yourself from the body's needs, as in some Eastern cultures (Shusterman, 2009, pp. 138–139). The fact that we are corporeal means that our biological prerequisites in height, weight, age, and general condition, constitute individual bases for perception and action. *Extended* is the condition that we have been dependent on tools, and in modern times computers and phones, to be able to function. When we make a note, our memory is expanded to the written sheet. *Enactive* means that you actively relate to your surroundings. To be physical active. It is mandatory for living that we move, see, breathe, and actively reach for objects, to adapt to the environment. Professor specializing in embodied cognition, Theresa Schilhab (2020), uses an example with the eye that sees; the eye, says Schilhab, actively moves in so-called stockades, and almost "feels" objects, to create a whole in the sensory impression. *Embedded* is the consequence, that the body is always situated somewhere. There are always surroundings that humans cannot be independent of. They can be natural or human-caused influences. In the field of educational architecture, research point out how space and materiality affect us (Bertelsen and Rosén, 2018; Kirkeby et. al. 2005). But to what extent are cognitive processes based on "simple" interactions between the body and the environment, and the situation and context in which they take place? Schilhab and Esbensen (2019) argue, through references to experiments, that self-regulating advanced cognitive functions such as working memory and cognitive flexibility, as well as attention control, are improved through exposure to green environments. The idea is that the materiality of nature activates neurological synapses automatically (bottom-up), freeing up time and energy for the cognitive functions that require our direct, focused attention (top-down). You charge the "batteries", so to speak. Schilhab and Esbensen refer to this theory as ART – Attention Restoration Theory. The sounds, colors, and general diversity of nature create an increased perceptual activity because the body enters a state of "soft fascination," and this releases energy for tasks that draw on mentally demanding cognitive functions. We become better at abstracting for external signals that would otherwise distract us from the task solution. In this understanding, nature acts exteroceptive, that is, independent of sociocultural influences.

COBS Change of body state

COBS, which means "change of body state", is a way the body reacts to its surroundings and is located at the core of our consciousness (Sheckley et al., 2016, p. 44). Experiences that change the state of our body happen when neurons in various parts of the brain react simultaneously. They each "fire" (fire together). Even though the neurons have nothing to do with each other, they react to the same experience and are thereby connected to each other (wire together) through electrical impulses. The connections of the brain can thus be put together in innumerable new ways, hence the expression that the brain is "plastic". This creates an FTWT: Fire together – wire together circuit, which, by forming an experience, expands the field of our consciousness. It is the body's way of improving its ability to react better and more appropriately the next time a COBS occurs. It may be that if a student gets a splinter in their finger in woodworking class, greater attention will be paid the next time wood is taken in their hands. The more violent the experience with the splinter, the greater the caution in the future. These neuron connections help us change and adapt our behavior. In the theory of "dialogue of the process" (Illum, 2004), Bent Illum examines the process by which a child gradually becomes better at driving a nail in, in the interaction between hand, hammer, nail, board, eye, surface, posture, and the intent of the action. Here there are many consecutive FTWTs, which are constantly replaced, take over, and help each other to better perform the task as the neurons fire. The sound when the nail is hit, changes, and is registered by auditory receptors as it is struck further down and depending on where on the hammer's trajectory surface you hit. You should not hold too little, nor too much on the nail, and the item the nail is driven in to, must be secured, and you might have to drill a little hole in advance to guide the nail and make sure the wood doesn´t split. Many simultaneous processes are in play, and it is not enough to present the formal, rational explanation that nails just need to be hammered in. It requires practice, mistakes, and experience with external factors such as the thickness of the nail, the weight of the hammer, the hardness of the wood and through interoceptors for the condition of the body. And not least all the signals that come from classmates in the classroom. The ability to focus requires several conscious choices and de-choices in each situation. We make the decisions as embodied in the body, embedded in the surroundings, engaged in the performance of the task, and extended out in the tool.

The neural correlate

For the human being, who is a speaking being who communicates primarily with words, these words can recall situations, moods, feelings, and patterns. The connection between our behavior and brain activity, the bridge between the sociological and biological view of learning, is called the "neural correlate" (Ejersbo and Steffensen, 2014). The neural correlate is the modal structures we draw on when we hear the word "plane". There might not be a plane physically represented, and then we will draw on the experiences we associate with the word plane. It can be the feel of the tool, or the use of it stored through the activation of the nerve pathways of the fingertips, or you feel the shocks through the hands and shoulders because the razor-sharp edge cut to deep and chipped, due to incorrect alignment. It may be that your body relates to a pain in your back or hands from incorrect use the last time you used one, and you will then be less likely to reach for that tool again. Based on a single word, there will be activity in the brain's motor system, and other neurons will fire for surface, edges, and function. The brain will place these modal structures in a hierarchy that determines how the object presents itself to the individual (Schilhab, 2014, p. 57). This is an important notice, as you can never know how a word or a task correlate with a pupils embodied cognition. But you can thoroughly prepare how to present the condition and use of the tool, so it will correlate with the intended teaching or task ahead. This is one obvious reason for the necessity of skilled craft educators.

Collins' expertise and working memory

The British sociologist Harry Collins presents the concept of interactional- and contributory expertise (Collins, 2004). Interactional expertise is a way of acquiring specialized knowledge, by talking long enough with experts in a field, but without being able to conduct the science or craft of the subject in question. He brings an illustrative thought experiment about the lion and the chair. Most people know the term chair as a collective term for the types of furniture that are intended to sit on. It is quite natural for us, as a concept learned through the body. Wild lions don't have a word for chair, since the chair isn't part of their world and therefore obviously don't use it. But if you imagine that a lion could talk and was brought up in an environment with humans, it would be able to learn the word "chair" and understand how and what it is used for. In this way, we can learn about concepts and working methods we have never experienced or assessed sensuously. Collins argues that most of the knowledge today is based on interactional expertise. Considering this, it could influence how a lot of teaching starts. In the sloyd class, a plane is introduced to the pupils without them yet having the same bodily experience as the teacher, who may have practiced over many years, and therefore they do not draw on the same conceptual understanding through the neural correlate. The conflict in sloyd, and teaching in craft and design could be, that something is well-intentioned introduced with too many words. The teacher expects the students to become interactional experts in miniatures in a brief time. But words received by the brain's receptors as deductive top-down learning draw on the cognitive resources of our targeted attention. The experienced crafts teacher possesses what Collins calls a contribution expertise, where you through training and testing, contribute to the current knowledge.

With the Aristotelian forms of knowledge (Christensen et al., 2018), one would call it *theôria*, the theoretical knowledge that one gains through application and experience, and *khrêsis*, user knowledge that has the tool as a means of achieving expertise and virtuosity. The teacher must therefore only introduce the most important tasks in a well-planned context, considering the thickness of the material provided, the sharpness of the tool, a solid workstation, etc. The information we present to our pupils and students is first transmitted through, and processed by, the working memory, and then stored in underlying memory structures. But it is not certain that they will get that far. The working memory is like a bottleneck, and just like a desk where you sort your information, depending on its size, too much information can very quickly arrive (Ejersbo, 2013). The working memory processes and coordinates all conscious information from visual and auditory impressions. At the same time, it tries to retain verbal information through the phonological loop. This means that you try to repeat words repeatedly until you can remember them, and research has shown that it is easier to remember words that make sense to you, as opposed to nonsense words that you quickly forget (Ejersbo, 2013, pp. 67 -70). There are a lots of nonsense words in the field of sloyd and craftmanship, and if too much amodal data is passed through the "desktop", the brain gets mentally tired, concentration fails, and the messages disappear. By combining words (top-down) with practical exercises that include unconscious (bottom-up) sensory modalities, you can, as with ART, increase concentration, the field of learning, and the body's ability to acquire knowledge. Therefore, it can be difficult for a student to meet a plane for the first time with only words, and not know how or what the plane will be used for. One can try to imagine the amount of information it will phenomenologically produce, depending on how the child observes it: the weight may be the first thing that is noticed. The student tries to sense the volume by moving their hands up and down, while holding the plane out in a slightly extended arm. Your pupil might look over at a classmate to see if there is a similar wondering reaction to the phenomenon of the sharp blade. The surface is smooth, lacquered wood, the cold metal and the screw in the cap iron that holds the plane iron clamped in place, is a material contrast to the rounded, soft shape of the protective handle. At the front there is also a handle, the horn, which invites you to touch and grab its twisted, slightly crooked shape. The sharp edge at the end of the blades bevel will invariably be touched with a fingertip, and the rest of the various parts of the plane. The wear marks, the shape, the colors, the numbering on the tool, and the scratches in the sole may be noticed and felt by the eye's sentient stockade while the tool is being turned with one or two hands. The neurons fire wildly. A tactile and modal structural language is established and stored for the beginner.

Pattern recognition

Biological beings are autopoietic. It is a condition of life, the instinct of self-preservation that makes organism search for food sources to exist. Our cognitive abilities have developed from this, aiming at being able to protect us from dangers, whether it is rotten food or threatening behavior (Schilhab, 2013, p. 85). Prediction based on signs is thus one of the most important tasks of cognition and ensures that the body is regulated towards appropriate behavior. These signs, which our environment provide, are shaped by our cognition through pattern recognition. It applies to all living animals that the world in which they live changes, and that they must therefore constantly adapt to their surroundings. Schilhab (2013, p. 86) refers to the researcher Sheets – Johnstone, who describes how the worm and the beetle, when they walk and crawl on the ground, must constantly regulate speed and direction, and sense their way forward in the terrain. This is done based on decoding the semantic signs of the surroundings: moisture, bumps, slope, movement, heat. This results in an infinitely correction and changing system of patterns, the properties of which we store in the body. Often on an unconscious level. Similarly, there is a search for patterns before we do anything, such as going into a sloyd class. There will be recognizable patterns shaped by the architecture. The lack of chairs nudges the student to sit down on the tabletop of the workbench. One student on each bench if there is enough. They also look for the best bench, based on their experience of the location in the room. And where are the friends sitting? Socialization thus also forms patterns. In this process of exploration and selection, the student connects the situation to something previously experienced, drawing on conscious as well as unconscious sensory modalities, and then forms some expectations of what is about to happen. These expectations can be explained as a ubiquitous "situated conceptualization" that lies as a foundation for our learning.

Situated Conceptualization

The first time the students are to have a sloyd class, there is an expectation of entering the workshop area. They haven't been there before. Perhaps once, some years ago, making nail boards with a teacher. Now it's their turn to enter the magic of this woodworking classroom and its sphere of smells, sounds and engagement! Expectations are high. Before they enter, there are many different ideas about the workshop, which appear differently for each pupil, based on their previous experiences with a workshop and the words associated with a workshop. It´s not certain that everyone has equally good experiences with this type of room. Some may have heard that there are dangerous tools and therefore become unsafe, or they have tried to cut themselves on the tooth of a saw in kindergarten. Others have good experiences from home and have tried to work with wood with their parents or in the club. But common to all, is that they connect the current situation with memory, senses and experiences that are tied to a previous situation. This expectation of what is going to happen and what the pupil associates with being in a workshop is called situated conceptualization (SC) and is a central concept in embodied cognition. The American psychologist Barsalou, (2016), puts it this way:

> "Together, the coherent perceptual experience and conceptual interpretation constitute a situated conceptualization." (Barsalou, 2016, p. 6).

This means, that a situated conceptualization is all the cohesive perceived impressions that different areas of the brain put together into an overall impression of how it feels to sit in a coffee shop and drink coffee, or be in a sloyd workshop, the moment you meet the coffee shop or the sloyd room. A kind of memory that contains sensory stimulation. The brain, says Barsalou, is designed to process situations in the moment, and at the same time simulate past experiences from memory (Barsalou, 2016, p. 6). Associative mechanisms create a language for the experience that is stored in the long-term memory, so that one can compare with and draw on the experience later. It is thus a complex, eternally repeating mechanism that we decode and ascribe meaning to our surroundings. In the same way as with pattern recognition. When situations begin to resemble each other, drawing on the same types of experience, these situations will begin to appear exemplary. The child will have one expectation of the sloyd workshop the first time, and if some fixed routines gradually begin to be established, such as a fixed seat, or we sweep after ourselves when we are done, then these representations of surroundings and discipline will be the most likely to draw on the next time an expectation of this room is created. It can also explain why a teacher has expectations of receiving a new class, or why the student suddenly changes his behavior when there is a substitute teacher.

Rounding

Crafting is a mentally demanding process that creates a dialogue in the practitioner through interaction with the material, and the work processes draw on both modal and amodal structures. It is crucial to understand that the presentation of a plane for woodworking provides a direct modal-specific experience for a student that does not necessarily correspond to the description of this tool that comes from the teacher. The tool must be experienced through exercises that match the student's level of mastery. This means in concrete terms that the teacher must select wood that is of a nature that makes it easy to process. It must not be too hard or too thick, or with too many knots and uneven grain, without this being considered in the instruction. All these reservations can be seen as amodal parts of many overall modal-specific experiences. To begin with, this happens at a context-independent level, with easy exercises, where the novice can focus his attention on the given task: e.g. producing shavings that match the length of the piece of wood and making a decoration out of it. In the amodal framework, small parameters can be changed to make the overall mastery experience better for the student. The article has attempted to show how many impressions can be encountered by the user of a tool and described how the brain's neurons fire wildly and create new learning when encountering external impulses. Semantic schemas for theoretical practice require one's targeted attention (top-down) and are learned and stored bodily after a prolonged period of practice. The pupil's "embedded" and bodily anchoring actively involves the surroundings in the learning area as material anchors (bottom-up). With the inclusion of concrete objects, the thinking about sloyd becomes bodily and multifaceted, which often makes it easier to enter a collective understanding with others; to help each other, to see and appreciate the work of others, and to get credit for one's own. As well as developing creativity and computational thinking. The experiments with ART can explain why working with craft can create extended periods of concentration in students, and that the subject can work well outdoors with example, green sloyd, the art of carving spoons, bowls and basic furniture with freshly cut wood and hand tools, as the bottom-up sensory perception adds energy to the targeted attention. Provided that tools, materials, and techniques, are introduced and assigned to pupils in the right quantities and quality. It´s my sincere wish that the article can inspire the approach of teaching sloyd with a renewed curiosity on the way we respond to our surroundings and the presentation of tools and materials. A contemporary conflict lies the fact that the ability to teach these amodal representations which are crucial to learning creativity through sloyd, is less prioritized with the cuts in teacher education as mentioned in the beginning of this article.

When professional expertise and basic rules for the acquisition of sloyd knowledge is combined with the four E' s of embodied cognition, it is possible to create sensually stored, theoretically meaningful teaching in sloyd, that will become a lasting part of the student's further experience.

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