Transforming physical materials into artefacts
– learning in the school's practice of Sloyd

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This article describes learning and interaction in the practice of Sloyd [Craft and Design, sw. Slöjd] when pupils in the school's practice of sloyd work on and transform material into a sloyd object in the Swedish comprehensive school. As an aid in depicting how cultural socialisation and learning in the practice of sloyd in school can be formulated, we make use of video-recorded empirical data from sloyd lessons in comprehensive school. Based on the empirical data collected, it is particularly important to analyse how communication during sloyd work takes place in the form of not only talk but also non-verbal interaction (body language, gestures, mimicry, etc.) and other tool-mediated activities. Also of interest is the environment where learning takes place, for example, how the classroom for sloyd is furnished, accessibility, selection of tools and materials. Since only parts of the practice of sloyd have been scientifically described, all the conditions that affect interaction and learning in sloyd classrooms are of importance (Lindström, Borg, Johansson & Lindberg, 2003).

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Learning in Sloyd

The Swedish word "slöjd" [eng. Sloyd] comes from an old Swedish word, "slöghp", meaning cunning, diligence skilfulness, knowledge and wisdom and from "slögher", the quality of being handy, deft, craftsmanlike, dexterous, experienced, skilled, resourceful and ingenious (The Swedish Academy Dictionary [Svenska akademins ordbok, band 28], 1981). The concept of sloyd was mentioned as early in the Swedish code of law called Östgötalagen in the 14th century. However, the subject of sloyd's knowledge area is older than that. Transforming physical materials into artefacts with the help of tools has always been done and is fundamental for our existence (Liedman, 2006; Säljö, 2000, 2005, 2008). The subject of sloyd is unique in that it enables knowledge 'to be built into' an object; sloyd is making physical artefacts. Here, the subject of sloyd offers a form of learning that differs from most other school subjects. Both work process and result are clearly visible to the pupil. The subject of sloyd's qualities is valid in today's society but perhaps not sufficiently clarified in the teaching of sloyd.

The lack of research results may contribute to sloyd activities remaining hidden. What and how pupils are able to learn from sloyd lesson risks 'remaining in the classroom for sloyd'. Classroom activities could remain unreflected and not attended to by both the persons in the classroom and the persons discussing the justification of sloyd in today's school. Learning can be perceived as either self-evident or incomprehensible, which is something that has emerged in the national evaluation of the subject sloyd in the Swedish comprehensive school (Swedish National Agency for Education [Skolverket], 2005, 2007). How can we learn something about the complex learning environment of sloyd? One way of getting at what is hidden is to videotape lessons and document how pupils learn sloyd in the school's sloyd practice. Earlier studies by Illum and Johansson have depicted parts of this complexity (Illum, 2004a, 2004b, 2006a, 2006b; Johansson, 2002, 2006, 2008a, 2008b, 2009).

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Illum's doctoral thesis *Manual handicraft and learning – a matter of dialog between the material and the craftsman [Det manuelle håndvaerksmæssige og learing – processens dialog]*, (Illum, 2004a) focused on verbal and non-verbal communication, embodied learning and learning in situations between the competent person and the novice. Johansson's doctoral thesis *Craft and design in school – hand, mind, communication and other mediating tools [Slöjdpraktik i skolan – hand, tanke, kommunikation och andra medierande redskap]* (Johansson, 2002) dealt with, among other things, pupils' and teachers' actions using mental and physical tools in the practice of sloyd in the Swedish comprehensive school. Both theses were based on videotaped recordings of sloyd being taught in secondary school. Apart from Illum's and Johansson's studies, very little of the teaching of sloyd in secondary school has been described on the basis of videotaped empirical data. With previous research results as the starting point, the focus of this article is to describe, on the basis of new empirical data, how learning processes are developed both with physical experiences and together with other persons during work in the sloyd classroom.

Classrooms for sloyd are both similar and different from other classrooms in secondary school. They are rich in physical and aesthetic experiences as a result of machines, instruments, tools, different hard and soft materials, smells and sounds. Sloyd is communicative in several senses, the pupils do not sit still for any length of time, they work in several different places and switch between being given help and helping each other (Illum, 2004a, 2004b, 2006a, 2006b; Johansson, 2002, 2006, 2008a, 2008b). But when the pupils in the Swedish evaluation of the subject sloyd in secondary school answer questions about how the work during sloyd lesson, they say that "they work independently" (Swedish National Agency for Education [Skolverket], 2005, 2007). Are the pupils referring to working on a sloyd object of their own, or do they mean that if the object is to be given to somebody else, they were still alone when they made it? Illum (2004a) points out that both the visible result in the form of the object can overshadow the work process, where its dialogue takes place, and the pupil's experiences during the process's dialogue can contribute to the pupils shutting themselves off from the communicative aspects of their work.

Multidimensional communication and learning

To be able to discuss learning and communication in the practice of sloyd, we will employ a sociocultural frame of reference. Our perspective is based on Vygotsky's theories (Vygotsky, 1978, 1986, 1995) on the use of different tools – resources for learning – a perspective that has been developed by a large number of researchers (e.g. Dyste, 2003; Kozulin, 1998, 2003; Säljö, 2000, 2005; Wertsch, 2002). The world is mediated to us with the help of physical and mental tools. Based on our social and cultural experiences, the tools become aids in interpreting, taking standpoints and acting. In sociocultural theory, a broad social science concept of culture, which includes both material and immaterial dimensions, is employed. Ideas, values and knowledge are acquired through interaction with the surrounding world. Culture also includes physical tools, there is close interplay between these dimensions (Säljö, 2000, 2005). In the sloyd classrooms there are several physical tools such as scissors, hammers or materials for sloyd work. Tools also refer to mental, intellectual tools and all the resources used when pupils learn to do sloyd both in interaction with other pupils and with artefacts (Johansson, 2002, 2008a, 2008b, 2009). Learning sloyd also involves acquiring experiences and knowledge of processes and mastering the dialogue of the process (Illum, 2004a, 2006a). These processes and learning situations also apply to apprentices in master-apprentice situations (Lave & Wenger, 1991; Rogoff, 1990). Physical experiences and knowledge, for example, learning to tighten or press "the right amount", i.e. not too little and not too much, are mastered during the dialogue of the process between person, tool and material. Of interest are more detailed studies of how pupils can gain experiences by doing sloyd, how they learn to utilise these experiences and how knowledge is passed on.

Illum's studies (2004a, 2004b, 2006a, 2006b) have shown that there are variations in how communication is affected by the physical element in the sloyd classroom. In several of the school subjects, verbal communication is prominent in the classroom. When the pupils are occupied with working on their sloyd object, verbal communication with the teacher may seem limited but it is complemented by rich non-verbal communication. Sometimes the teacher's verbal instructions are not enough. The external or social situation-related verbal communication that takes place in the sloyd classroom can, according to Illum, be characterised as "parallel communication", "narrative communication" and "summarising communication". Illum's studies have shown that commonly occurring communication – by the pupil who knows more with the pupil who knows less – takes place in the form of three-dimensional instruction together with very simple verbal communication, e.g. "You do like this" or "Look, like this", while the verbal communication – from the pupil who knows less with the pupil who knows more – contains short questions such as "How?", "Is it good now?" or "How do you do it?" (Illum, 2004a).

Johansson's studies have shown how learning in the sloyd classroom is created by interaction with others and in interaction with mental and physical tools. In the thesis (Johansson, 2002) the conclusions were presented in the form of four themes: "Interaction, verbal and non-verbal communication"; "Tools and machines"; "Sketches, pictures, drawings and instructions"; and "Materials, sloyd products, aesthetic and emotional experiences". Learning sloyd is communicative in several senses, several resources are integrated in the work. Both physical tools, sketches, or materials as such, together with the persons in the classroom, are used as aids for thinking during learning. Tools, sketches and materials give, and are given, meaning together with the persons in the sloyd classroom. During their work the pupils are able to get at the 'built-in knowledge'. The pupils switch between being the person who is most knowledgeable when they work from idea to finished sloyd object. Studies have shown how sloyd work is complex in several ways, there are several abstraction processes and decisions that have to be coordinated when pupils work on creating a contemplated object (Johansson, 2002, 2006, 2008a, 2008b, 2009). In this article, there is a focus on learning as both an external social concept and an internal physical phenomenon. The new empirical data can be seen as a further development of the theme "materials, sloyd products, aesthetic and emotional experiences" (see above, Johansson, 2002).

In all scientific analysis work, it is important for the reliability and validity of the results that the person analysing is clear about his/her pre-understanding (Agar, 1980). In analyses of sloyd processes, which also include physical skills and knowledge of sloyd work, a researcher experienced in sloyd work can take his/her own physical experiences and knowledge into consideration in order to discern depth and breadth (Illum, 2004a; Johansson, 2002). The videotaped material on which this article is based was acquired in full compliance with ethical rules. When empirical data are to be collected in conjunction with sloyd work, it is important to choose a method that is best suited to collecting relevant material in relation to the problem field to be investigated. Making sloyd objects in the classroom most often takes time and spans over several lessons and contains, among other things, problems which means that the research method must be able to document actions over time. Many of the more common research methods can be rejected as they do not enable the researcher to gather empirical data on pupils' actions over time. Video recordings of on-going actions over time are a possible method of documenting learning *in* the practice of sloyd, a method also used in contexts where the aim is to capture learning as an interactive phenomenon (Goodwin, LeBaron & Streeck, 2011; Knoblauch, Schettler, Raab & Soeffner, 2009; Rønholt, 2003).

In the case of videotaped empirical data, consideration must be paid to the fact that every video sequence is the result of a choice and, thus, one or more choices not selected. The sequences chosen can therefore be seen as the first interpretation of the activities by the person doing the videotaping. What is then discovered in the material depends on the perspective chosen. Accordingly, it is necessary to be clear about what the purpose of the analyses is and the categories chosen when considering the material. The focus of the analyses is an

interest in both what pupils and teachers say and, not least, what they do, both physically and tactilely, as well as any other actions that can be observed in the video recording (Goodwin, 1997; Goodwin, LeBaron & Streeck, 2011; Heath, Hindmarsh, & Luff, 2011; Knoblauch, Schettler, Raab & Soeffner, 2009; Rønholt, 2003). In this article, we have chosen to study in greater detail how learning is developed both socially and physically when pupils in the school's practice of sloyd work on and transform material into a sloyd object.

Work on a copper bowl

We open the door to a sloyd classroom for woodwork and metalwork and meet pupils in their fifth school year. The sloyd group consists of half a school class; the other half are having a lesson in textile craft. The area for wood- and metalwork is in the basement and has smaller rooms right next to the sloyd classroom where wood is stored and painting is done. The sloyd classroom is furnished with carpenter's benches, workplaces for metalwork and machines. On the walls are cupboards for materials and accessories as well as different tools. During the videotaping sessions – over several consecutive weeks during the term – the pupils work on sloyd objects they had chosen themselves such as wooden bowls, copper bowls, stools, shelves and jewel boxes. There is a lot of activity, the teacher gives instructions by helping one or more of the pupils. He talks at the same time as he keeps an eye other pupils' work from a distance. Even though the teacher is "at a distance", he is aware of how the machines sound. The teacher's auditative attention takes the form of ignoring all known and accepted sounds and focusing on unknown or undesirable sounds and then taking action.

Mikael and *Linus* have chosen and begun at the same time to work on and form a flat sheet of copper into a bowl. Linus was absent from one sloyd lesson when Mikael cut out the round sheet of copper with the help of a plate shears and smoothed its edges with a file. During this initial work with the sheet of copper, the material, the pupils gain experience of how a sheet of copper feels "generally hard" when it has not been worked on. A starting point they use to be able to perceive differences when the material is instead sufficiently soft. Mikael could be considered "lively" (and sometimes a rather rowdy) pupil, he often walks (or runs) around in the sloyd classroom, talks to other pupils both about activities outside school and work in the classroom, helps other pupils and watches other pupils working and getting help from the teacher. He learns by standing next to other pupils, which is also a common way of learning in everyday and professional life (Jernström & Säljö, 2004; Lave & Wenger, 1991; Nielsen & Kvale, 2002). When Mikael is working on his future copper bowl, he does so intensively and by fits and starts. He 'takes a break' from working on the bowl by taking a walk around the classroom and then returning to work zealously. At the beginning of the lesson, before beginning to work on forming the sheet of copper, Mikael (and Linus) goes up to the teacher:

Excerpt 1: Beat, beat

Part a

Who	***Does what***	***Says***	***Other***
1a:1 Mikael	Comes and stands next to the teacher (who has just helped another pupil).		Linus stands next to the teacher on his other side.
1a:1 LÄR	Turns to Mikael.	*Then you could beat.* *So go and fetch a hammer.*	
1a:2 Mikael	Beats with his hands.	*OK! Beat, beat!*	Mikael and Linus go off.

The teacher turns to Mikael but addresses both of them when he says "you" (1a:1 LÄR) and seems to assume that Mikael and Linus know what hammer they (Mikael) should fetch.

A bit later, Mikael is using the hammer to "beat, beat" the piece of copper he has cut out for his copper bowl. Linus comes up to him. They are both wearing ear protectors and Linus, who has not yet begun to beat the piece of copper for his copper bowl, stands beside Mikael and watches him beating the outside edge (which as a result gets harder and harder) of his future copper bowl.

Part b

Who	***Does what***	***Says***	***Other***
1b:1 Mikael	Hits around the outside edge of the round piece of copper with the hammer.		Linus stands beside him and watches.
1b:2 Mikael	Looks at Linus. Using the hammer, he indicates the edge of the future copper bowl.	*Look!*	Linus watches.
1b:3 Mikael	Turns the copper bowl. Continues to beat the edge. Repeats.		Linus watches.
1b:4 Mikael	Stops. Squats down and looks at the edge he has beaten from the side. Smiles at Linus. Starts beating again.		Linus watches and smiles.
1b:5 Mikael	Beats. Rests his arm. Changes hands. Beats some more.		Mikael swings the hammer more slowly. (Seems to be tired in his arm)
1b:6 Mikael	Stops and rests. Looks at the edge of the copper bowl.		Linus watches concentratedly.
1b:1 Linus	Feels the edge of the copper bowl with his fingers.	*Now it's the other way.*	Goes closer. Bends forward.
1b:7 Mikael	Also runs his finger around the edge of the copper bowl.	*Yes, … already getting a really bad arm ache.*	Rests his arms.
1b:8 Mikael	Continues to hit with heavy blows along the edge, which is now slightly bent.		Linus watches.
1b:2 Linus	Points and feels the bent edge of the future copper bowl	*It'll be good 'cos you should hammer more here.*	Mikael stops hammering and also runs his finger around the edge.
1b:9 Mikael	Continues beating, rotates the bowl, beats. Stops.	*Should I beat a bit more?*	Linus watches.
1b:3 Linus	Points around the inside of the future copper bowl.	*Well, it'll be good 'cos you should hammer more here!*	Mikael watches.

1b:4 Linus	Points at the bowl.	*A small plate!*	Mikael watches.

Only Mikael is hammering on the copper bowl and is thus learning physically, via the dialogue of the process, how the hammer functions in relation to the material in the process. However, Linus stays and watches carefully. Mikael seems to appreciate Linus' involvement by saying "Look!" (1b:2 Mikael) and then they smile at each other (1b:4 Mikael). Mikael's arm gets tired and he rests between hammer-blows, which get slower. Linus gets involved in the work by feeling the edge of the future copper bowl and declaring that it is now bent (1b:1 Linus). Mikael asks Linus if he ought to hammer more on the edge (1b:9 Mikael), but Linus says that he has done enough for the time being and that the bowl looks like a small plate (1b:3-4 Linus).

After watching a while, Linus asks whether Mikael is really using the right sort of hammer so Mikael goes over to the teacher with his hammer and the teacher verifies that it is the right hammer. Mikael continues to beat the bent edge of the future copper bowl with the hammer. During this work process, Mikael is fully occupied with the encounter with the material, what Illum calls the dialogue of the process (Illum, 2004a). The encounter with the material is physical and is used to decode the state of the material and the progress of the work, which can also be seen in 1b:7 when Mikael feels the edge of the copper bowl with his fingers. After even more hammering around the now bent outer edge, Mikael goes to the teacher once again:

Part c

Who	***Does what***	***Says***	***Other***
1c:1 Mikael	Stands next to the teacher.	But it's really hard work!!!	Several pupils stand around the teacher.
1c:1 LÄR	Stands in front of Mikael.	Yes, but then you've… Then perhaps you've finished. That it's so hard that you can't beat it more.	Mikael listens.
1c:2 LÄR	Looks at Mikael and nods down at the bench.	Fetch the gas cylinders and clean up there so that we can burn.	Mikael listens and then moves towards the bench.

Mikael thinks that it is hard work hammering on the copper bowl (1c:1 Mikael). The teacher says that probably the future copper bowl is no longer soft enough, it is too hard to beat. In this way, the teacher gives Mikael an opportunity to acquire a physical feel for and understanding of what the copper is like when "it's so hard that you can't beat it more" (1c:1 LÄR). The teacher asks Mikael to go and get the gas cylinders "so that we can burn" (1c:1-2 LÄR). The teacher says "we", which could be interpreted as meaning that he is going to help.

Even though the teacher said that the copper bowl was too hard to beat anymore, Mikael continues to hammer his bowl a bit more and calls to the teacher (Jonas):

Part d

Who	***Does what***	***Says***	***Other***
1d:1 Mikael	Continues to hammer.	Jonas…, doesn't it sound like it's too hard now?	Linda and Anna stand next to him.
1d:2 Mikael	Continues to hammer.	So where are the gas cylinders?	Linda and Anna stand next to him.

While Mikael is hammering on the copper bowl, he wants the teacher to listen whether it possibly sounds as if the copper bowl is too hard to continue to hammer on, "doesn't it sound like it's too hard now?" (1d:1 Mikael). Here, it is sensorily and auditively possible to hear the auditive response from the dialogue of the process and on the basis of physical experiences, determine whether the copper has become to hard from being beaten.

Linda and Anna are standing beside him when Mikael asks where the gas cylinders are (1d:2 Mikael). Linda points at the cupboard where the gas cylinders are stored. Mikael looks at the warning sign for bottled gas on the outside of the cupboard and opens the cupboard door but does not lift out the gas cylinder. The teacher, who is standing a small distance away, notices this and says "just lift it out", but that Mikael "must be careful". Anna repeats the teacher's comments about being careful to Mikael. Mikael seems to be somewhat uncertain and asks Anna to help him. They then carry the gas burner over to the bench.

Heating up copper with the gas burner and cooling it with water

The gas burner is in position and Mikael, Rickard and Linus remove the pieces of wood around the gas burner on the bench:

Excerpt 2: Igniting the gas and burning

Part a

Who	*Does what*	*Says*	*Other*
2a:1 Mikael	Calls to the teacher (Jonas).	Jonas, I'm ready! Ready to burn!!! Jonas, I'm ready!	Linus stands close to the bench.
2a:1 LÄR	Helps other pupils.	Very good. I'll come over in just a couple of moments.	Mikael walks around the room, waiting in turn. The teacher helps other pupils. In the background, the pupils are noisy.

Mikael calls to the teacher, who is busy with other pupils and nevertheless answers with an encouraging "Very good" and that he will come and help "in just a couple of moments" (2a:1 LÄR). Mikael walks around the room, looking and talking with other pupils while he waits his turn.

Mikael is waiting for the teacher to come and show him (3-dimensional instruction) how to use the gas burner on the copper bowl. He impatiently waits his turn, as there are many pupils who want the teacher to help them. After a while, it is Mikael's turn to get help. The teacher places the gas cylinder on the floor.

Part b

Who	*Does what*	*Says*	*Other*
2b:1 LÄR	Picks up Mikael's future copper bowl and hands it to Mikael.	You've hammered it and now it's really hard. Feel it!	Mikael tries to bend the edge of the copper bowl.

2b:2 LÄR	Places the bowl on some bricks.	Ah…, it's not possible, right?! What you've done is to hammer the atomic structure. …so now it's really hard. Now we'll heat this up with the gas.	
2b:3 LÄR	Open the cock on the burner. Holds his hand in front of it.	Can you hear the sound?	Mikael watches. Several pupils have come close and stand watching the work.
2b:4 LÄR	Holds up the burner.	And it smells a bit like a fart, right?	Mikael leans forwards and smells and snorts. More pupils smell it and comment that it smells disgusting.
2b:5 LÄR		But Mikael, I'm telling you that bottled gas is odourless. It doesn't smell of anything. So why does this smell? … So that you know if it's leaking… If it's leaking then somebody would say; oh, who's farted…	Mikael holds his nose with his pullover.
2b:6 LÄR	Lights the gas at the nozzle with a lighter.	I'm lighting it. Now we're going to heat it up. So that it turns really black. So you really see how it's glowing and shining with the heat.	Several pupils are watching. It is exciting!
2b:1 Mikael	The teacher gives him the gas nozzle.	Well…	When Mikael is holding the nozzle, the teacher stands next to him for a while to make sure that he is handling it properly.

The teacher tells Mikael to feel for himself that the copper bowl is too hard to hammer on and Mikael verifies tactilely that the copper is no longer soft by demonstrating that it is impossible to bend the edge of the copper bowl (2b:1 LÄR). The teacher says that that is why they are going to heat it up with the gas (2b:2 LÄR). Several pupils are standing around the gas burner. It is both exciting and fun when the teacher allows them to smell the gas! This gives the pupils a physical experience of the smell of the gas at the same time as the teacher communicates verbally as to why the gas has this smell for safety reasons. This multidimensional communication continues when he lights the gas (2b:3-6 LÄR). The teacher begins to heat up the copper bowl and explains that it will get "really black", adding that it is "glowing and shining with the heat", i.e. a physical and visual experience (2b:6 LÄR). Mikael hesitates a bit (2b1: Mikael) when he is given the gas nozzle by the teacher, but the teacher remains for a while Mikael heats up the copper bowl before leaving to help other pupils.

Mikael continues to heat up the copper bowl with the gas burner. Rickard and Linus stand close by and comment on the smell and watch Mikael. It is exciting! Mikael says that it is getting hot and asks the teacher, who is standing a short distance away, howl long he should continue, but instead it is Linus who answers:

"Until it's pitch black". Several pupils come up or walk past and comment on the colour of the gas flame and the copper bowl. Mikael asks Rickard to ask the teacher (who is helping a couple of other pupils) about when it is enough, when it is ready. The teacher answers in the background that it will soon be ready. Rickard, who was present during the teacher's demonstration "So that it turns really black" (2b:6 LÄR), comments that the bowl is now "totally black". The teacher says that Mikael can turn off the burner, but Mikael wants the teacher to come over and turn it off for him. The teacher and some of the pupils go over to Mikael:

Excerpt 3: A thousand degrees!

Who	***Does what***	***Says***	***Other***
3:1 LÄR	Takes the gas nozzle from Mikael and turns off the gas.	Now it's really hot! About a thousand, twelve hundred degrees.	The pupils watch.
3:2 LÄR	Picks up the hot bowl with a pair of tongs and goes to the washbasin.	We're now going to cool it down.	The pupils go with him to the washbasin.
3:1 Mikael	Goes with the others to the washbasin.	I don't think I'll touch it. It's a thousand degrees.	
3:2 Mikael		A thousand degrees…! A thousand degrees…!	The teacher fills the wash-basin with water.
3:3 LÄR	Places the hot bowl in the water.	Does it feel hot?	The pupils react with delight when it hisses.
3:4 LÄR	Picks up the bowl with one hand. Takes the bowl back to the gas burner.	We need to heat it up even more. It hasn't got as soft as it ought to have. We'll have to do some more [heating].	The pupils follow the teach back to the gas burner. Background noise.

The teacher turns off the gas and says that "it's really hot", i.e. he explains that his senses tell him that the bowl is really hot and he expresses this verbally by saying "a thousand, twelve hundred degrees" (3:1 LÄR). Mikael repeats "A thousand degrees!" (3:2 Mikael). This could be interpreted as meaning that Mikael links the physical impression of the symbolic knowledge with an overall perception of the nature of the material when he repeats "a thousand degrees".

The teacher lifts up the bowl with a pair of tongs and takes it to a washbasin a few metres away to cool it in cold water. The pupils react with delight (a physical experience) when it makes a hissing sound in the water (3:3 LÄR). At the same time, the pupils learn what they should pay attention to, they are socialised by their collective reactions. The teacher picks up the bowl and says that it needs to be heated up again because it is still not soft enough (3:4 LÄR). He says this after having felt how hard the material is with his fingers; i.e. the teacher transforms a physical evaluation of the hardness of the bowl related to his own embodied experiences in this area into summarising verbal communication.

With the teacher standing beside him, Mikael turns on the gas himself, but the teacher lights the flame. Mikael once again heats up his copper bowl. The teacher replaces the bottled gas cylinder. Mikael continues to heat up the bowl and the teacher comments on this, saying that "the bowl is almost sweating". Mikael turns off the gas. He picks up the bowl with a pair of tongs, goes to the washbasin and places it in the cold water

and in this way gains an experience of softening the beaten copper. Rickard goes with him. The teacher and several pupils go over to the washbasin:

Excerpt 4: This is soft enough!

Who	*Does what*	*Says*	*Other*
4:1 LÄR	Lifts the bowel out of the wate with his hands. Holds the bowl, presses with his thumbs and bends it	Feel it now!	Rickard stands close by.
4:2 LÄR	Hands the bowl to Mikael.	Do you remember how hard it was before?	Pupils watch.
4:1 Mikael	Holds the bowl, presses with his thumbs and bends it. Gives the bowl back to the teacher.		Pupils watch.
4:3 LÄR	Holds the bowl, presses with his thumbs and bends it.	Yes, it's much softer now! Yes, it is!	Pupils watch.
4:4 LÄR	Passes the bowl to the pupils.	It's much softer compared with before.	The pupils feel how soft the bowl is.
4:2 Mikael	Holds the bowl, presses with his thumbs and bends it.	I don't know what it was like then…	
4:5 LÄR	Passes the bowl to Rickard.	It was hard as a brick.	Rickard feels the bowl.

The teacher lifts the bowl out of the water, presses with his thumbs and bends it, saying: "Feel it now!". The teacher hands the bowl over to Mikael and wonders whether he remembers how hard it was before. Here, we see a teaching situation around so-called "silent knowledge transfer" when the teacher, based on his embodied experiences, assesses the result of softening and offers Mikael the opportunity of a physical experience of the result. In this way, Mikael gains an experience of what the copper material should be like when it has been correctly softened. Mikael is given the opportunity to feel how soft the material has become. It is not enough to verbally describe the feeling of softness, but by feeling the material before and after softening, the pupil acquires the necessary experienced knowledge of the material. Mikael presses and bends the bowl in the same way the teacher did (4:1 Mikael) and hands it back to the teacher. The teacher verifies once again by pressing and bending and says: "Yes, it's much softer now! Yes, it is!" while the pupils look on (4:3 LÄR). The bowl is passed round the pupils who feel how soft the bowl is now compared with before. Mikael says that he does not know what it was like before, but the teacher says that "It was hard as a brick" before and then passes the bowl to Rickard (4:5 LÄR) who gets to feel it once again. Every pupil learns physically, but the learning processes are also developed in interaction with other persons and with the physical environment in the sloyd classroom. The teacher points out that there is now oxide on the bowl and goes with Mikael and a few other pupils to the painting room. The teacher explains that the black oxide must be removed in an acid bath before Mikael can continue to hammer on the copper bowl, which is now softer. It is now time to tidy up as the end of the lesson is approaching.

During the next sloyd lesson, Mikael continues to hammer and form his copper bowl. Linus is working on filing his round sheet of copper, which will be his bowl, at the bench next to Mikael. They work, chat and comment on their work. Mikael hammers intensively but has to rest when he gets tired in his arm. Mikael

fetches the teacher, who hammers with a different rhythm. Mikael continues to hammer, but with a different rhythm more like the teacher's hammer blows. The teacher utilises master-apprentice learning, i.e. instruction, imitation and correction. The teacher carries out an instruction, which Mikael tries to imitate bearing in mind where the hammer blows land on the metal, but also taking into account the rhythm and sound of the blows.

Between working on his future copper bowl, Mikael makes a couple of rounds in the classroom. During one of his breaks, he helps Linus with the gas burner; Linus has now got to the stage where it is time to heat up his copper bowl. Mikael is now the "master" and Linus the "apprentice" because he is standing next to Linus without the teacher being present. Later on during the sloyd lesson, Mikael heats up his copper bowl by himself with the gas burner. However, the teacher is keeping an eye on Mikael and comments on Mikael's work with the gas burner and the cooling in the washbasin "from a distance" even though the teacher is helping other pupils. Several pupils are involved in the work on cooling Mikael's and Linus's hot copper bowls and they help with the water in the washbasin. It is exciting work! After the future copper bowls have been cooled in the water, the pupils feel them and in this way develop a collective experience – a collective memory of how "soft enough" feels (Säljö, 2005; Goodwin, 1997; Goodwin, LeBaron & Streeck, 2011; Martin, 2004; Wertsch, 2002). What is soft enough?

During the third lesson, Mikael continues to form his copper bowl with hammer blows. Like before, Mikael works in intervals on his bowl, rests his arm, walks around, talks and helps other pupils during his breaks. The teacher comes over to Mikael's bench now and then to instruct and correct. Linus's future copper bowl is beginning to take shape. The two boys work beside each other, they talk and compare their work. How the boys intend to work on their copper bowls is developed in a dialogue with the material, the tools and their surroundings. Mikael also works on Linus's copper bowl and corrects like the teacher, as a "master". In the same way, Linus is an "apprentice" when he stands beside Mikael and watches him using the gas burner. When Linus starts heating up his copper bowl with the gas burner, Mikael stands next to him for a while as support until he sees that Linus can do the work himself. Mikael and Linus switch between being the person who is most knowledgeable. The boys coordinate their work by placing their bowls in the acid bath at the same time even though Mikael is at a more advance stage than Linus.

What is soft enough? – Thinking with tools and materials

The learning pointed to and studied with the help of this microanalysis of videotaped situations in the sloyd classroom is largely physical in nature. The teacher instructs when necessary and encourages embodied experiences when he, for example, says "Feel it!" (2b:1 LÄR). He gives the pupil the opportunity to perceive the hardness of the material. In the same way, the teacher gives the pupils the opportunity to learn to see and feel the difference in the material, i.e. how soft it had become (4:1 LÄR). In order to emphasise the difference, the teacher asks: "Do you remember how hard it was before?" (4:2 LÄR). On this occasion, the teacher gives the pupil the opportunity to feel the difference, how the material felt before when it had been worked on to the maximum compared with how it felt after having been heated and cooled. The teacher also verifies when there is a difference between the two states of the material. This mediation ("transfer") of knowledge cannot only be described verbally, i.e. how soft copper looks and feels, but also by allowing the pupil to discover, learn and think with the material, his/her body can remember the difference (Illum, 2004a; Keller, & Keller, 1993, 1996). On the basis of previous embodied experience, the teacher is able later on to refer to the state of the material and hold verbal discussions as well as getting the pupil to acquire new physical experiences. The fact that the teacher himself masters these experiences can be seen when he lifts the bowl out of the water and says: "It hasn't got as soft as it ought to have" (3:4 LÄR).

The knowledge is shared with the other pupils and collective knowledge of what the copper material should look like and how it should feel to be sufficiently soft to continue working on is built up in the practice of sloyd. The physical environment, e.g. the classroom, tools, machines and books, together with the situation and the persons who are present, contributes to what is possible to learn (Johansson, 2002, 2008b; Gulliksen, 2006). Further light is shed on teaching sloyd as a sociocultural practice, with its dimensions of verbal and non-verbal communication and physical learning, in earlier studies by Illum (2004a, 2004b, 2006a, 2006b) and Johansson (2002, 2006, 2008a, 2008b, 2009). The videotaped excerpts of the work on copper bowls comprise only a few situations in a complex learning situation where pupils work on the basis of ideas on transforming material into sloyd objects. The microanalyses of the learning situations make it possible to discover in greater detail how verbal and non-verbal interaction is used in learning. Verbal interaction is used to make the pupil aware of the feeling to be focused on in embodied learning, e.g. (2b:6 LÄR) "So that it turns really black. So you really see how it's glowing and shining with the heat" or (3:3 LÄR) "Does it feel hot?". Language and action are integrated and a collective understanding is built up (Illum, 2004a; Johansson, 2002; Martin, 2004; Wertsch, 2002). The pupils are socialised in practice and also learn "counts" in the sloyd classroom. Their own experiences are mixed with collective experiences; meaning is created and cultural socialisation takes place in terms of how one learns sloyd in the classroom.

Learning about the nature of the copper material results in knowledge being acquired by the individual pupil, but it cannot be claimed that it is the teacher who has taught the pupil. The teacher, however, has, based on his experiences, marked important occasions during the course of the process where it is possible to acquire knowledge about this field. Similarly, knowledge is reproduced and created when Mikael and Linus continue working on their copper bowls. They switch between being the person who knows and giving each other support while they are working, e.g. (1b:2 Linus) "It'll be good 'cos you should hammer more here" or when Linda and Anna support Mikael when he feels uncertain and is supposed to fetch the gas burner from the cupboard with the warning sign on it (1d:2 Mikael) "So where are the gas cylinders?". Sloyd is clearly a communicative subject in several ways (Johansson, 2002). Pupils build up their own world of experience when they themselves acquire experience of how "soft enough" feels by listening, looking at, feeling and physically experiencing. The learning situations give access to previous experiences, both their own and others. During social interaction, together with materials and tools, a collective memory is recreated and created (Säljö, 2005; Wertsch, 2002). Experiences are acquired in interaction with the surrounding world, thought and action are built into these experiences (Illum, 2004a, 2004b, 2006a, 2006b; Johansson, 2002, 2006, 2008a, 2008b, 2009).

In addition to the knowledge of materials experienced by working on materials, the pupils probably learn much more, e.g. to understand an manufacturing process from idea to finished product, to feel a sense of involvement in their work and pleasure in what they are doing, to dare take the initiative and do something themselves and to evaluate and take a stand, to mention just a few of the qualities of knowledge that the subject sloyd is intended to promote (Swedish National Agency for Education, 2005). In the national evaluation of the subject sloyd in the Swedish comprehensive school the pupils say that sloyd is the subject in Swedish secondary school over which they have the greatest influence. The pupils state that they can utilise their own experiences and interests and take responsibility for their learning (Swedish National Agency for Education, 2005, 2007). These qualities may probably need to be emphasised more in the teaching of sloyd and discussed outside the sloyd classroom. Attitudes, ignorance and lack of research results in all likelihood contribute to the knowledge areas in the subject of sloyd being regarded as "simple" and perhaps even trivial and unnecessary in today's society (Liedman, 2006).

Being able to transform one's ideas with the help of tools into meaningful artefacts, experience the potential and limitations of the material, often in unknown problem-solving situations, brings alive the knowledge heritage from previous generations. Sloyd crosses boundaries in several ways, generations and different

cultures can meet in sloyd work. The subject of sloyd makes it possible to acquire knowledge and reduce unfamiliarity with materials and gain respect for sustainable development and environmental issues, which provide important insights when we live in an advanced material culture (Johansson, 2002, 2009; Säljö, 2008). This article gives examples of pupils' learning through the knowledge of materials they have acquired, the potential and limitations of tools and methods, and of how learning is passed on by the persons present in the sloyd environment. It is important to study learning processes empirically during sloyd work in order to better understand the learning and socialisation that take place in these processes. The subject of sloyd's knowledge area needs to be clarified, more research results are needed to be able to point to the contributions of sloyd, for example, taking the initiative (and daring to take the initiative), solving problems, getting an outlet for one's imagination, learning by creating, learning to think, communicate and form. In sloyd lessons at school, children and young people are given the opportunity during their childhood and adolescence to develop in the knowledge area "making physical artefacts", i.e. knowledge that is important for both their everyday life and their professional life.

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