Chapter 8
How Does Matter Matter in Preschool Science?

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8.1 Introduction

At the time of writing, it seems that "new materialism" has a stronger hold in research in early childhood education (involving children up to the age of 8 years) than in other grades. In this chapter, the term "new materialism" refers to contemporary work that rejects anthropocentrism and rethinks the role of matter in meaning-making processes. Such work has contributed important insights into how matter, and not only humans, produces possibilities and limitations in children's lives and in early childhood education practices. There are currently very few examples of new materialism work that specifically target *science education* in early childhood education. In an attempt to reduce that research gap, this chapter explores how matter matters in science education in Swedish preschools (for children aged 1–5 years).

8.2 New Materialism and Research in the Field of Early Childhood

Today, Western early childhood education (ECE) pedagogies and research are commonly shaped by ideals of putting the individual child in the centre of attention (Taylor, Pacini-Ketchabaw, & Blaise, 2012). Yet, a growing number of scholars challenge the idea of foregrounding individual children, by instead considering children as intertwined with the material parts of the world. One example is Karin Hultman (2011), who emphasises that children's relations with material things are

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very important parts of their lives, since material things offer opportunities for enjoyment as well as demanding attention. In 2012, the academic journal *Contemporary Issues in Early Childhood* had a special issue on "Children's Relations with the More-than-Human World". The articles therein revolve around how matter impacts on children's possibilities of acting and making meaning. The issue includes examples of how the materialities of the dressing up corner and the sandpit (Duhn, 2012) and the clock (Pacini-Ketchabaw, 2012) produce rules and boundaries that determine what children can do and wish to do. In other words, matter, and not only humans, actively dictates what happens in ECE practices. The editors, Affrica Taylor, Veronica Pacini-Ketchabaw and Mindy Blaise, proposed that this special issue "was the first of its kind in early childhood" (2012, p. 84). Three years later, Jayne Osgood and Miriam Giugni/Red Ruby Scarlet (2015) went so far as to suggest that there is a "material turn", a paradigm shift, taking place in early childhood education research.

Doubtlessly, the field of ECE research is a vibrant arena for rethinking the role of matter in educational settings. As Hillevi Lenz Taguchi (2011) points out, the agency of matter can be more demanding to children than any verbal instruction from teachers. For example, Lenz Taguchi writes about how the "agentic force" between a pile of buttons and a child's hand could bring about touching, picking and sorting buttons, no matter what the teacher's instruction might be. Similarly, Pauliina Rautio (2013) talks of how stones can call on us to pick up, organise and carry them. Rautio proposes this as an example of how children can engage with material things in repeated actions, so-called autotelic practices, without any apparent external reward. Further Hultman (2011) claims that in their investigative practices, children pose hypotheses *with* matter and not *about* matter, since "things whisper, answer, demand and offer" (p. 77, my translation). From my perspective, Hultman's statement strongly signals "science education", since it involves investigations and posing hypotheses concerning the physical world. Yet this is not Hultman's focus. In fact, it is rare that any of the ECE studies employing new materialism perspectives talk explicitly of science education. Still many of them target children's learning with the physical world, which in my view coincides with children's learning about science. One exception is the work of de Freitas and Palmer (2016), who rethink pedagogy around conceptual change and particularly scientific concepts. Drawing on a case of children building towers of plastic beakers, de Freitas and Palmer suggest that force and gravity emerge *within* the building activities, thus within the beakers-and-children relations, rather than force and gravity being static concepts that transcend the material world.

Apart from de Freitas and Palmer's (2016) work, why has there been so little explicit focus on science education in the research literature that employs new materialist perspectives on early childhood education? Possibly because, in many countries, science education has historically not been articulated or prioritised as part of the ECE curriculum. Nevertheless, science learning goals are increasingly evident in many ECE curricula around the world, and the related research field is expanding. I propose that there is much to gain from building on the body of new materialism and ECE research, if one uses an explicit focus on how science learning emerges in matter-child relations. Preschool is an interesting arena for exploring how matter matters to science education in general, since it is an educational setting for children as young as 1 year old, where practice cannot rely on children's verbal communication. Since adults are often so distracted by verbal language that children's relations with the material world go unnoticed (Lenz Taguchi, 2012), it is likely that in preschool, verbal language is not as much "in the way" for a researcher's attention to matter-child relations, as in educational settings for older students.

8.3 Agential Realism: Agentic Matter, Intelligible-Making and Intra-actions

In seeking to understand how matter matters in preschool science education, I find Barad's (2003) theory of *agential realism* potentially rewarding. Barad aims to bring matter back into a discussion that she perceives has been too dominated by human-centring and language. *Agential realism* suggests a radical new way of understanding how things come to be (Højgaard, Juelskjær, & Søndergaard, 2012, p. 67), which is closely tied to Barad's view of matter. While in most theoretical stances, matter is seen as passive, one key feature of *agential realism* is that everything, not only human matter, is agentic (Barad, 2007). Barad (2003) claims that everything always engages something else and that objects do not exist on their own but emerge in mutual processes that she calls intra-actions. Intra-actions are contrasted with interactions, where the prefix "intra" signifies what happens *within* relations, while the prefix "inter" signifies relations *between* objects. Thinking with *agential realism*, the perceived borders of an object, for example, my own bodily borders to the rest of the world, "become" as a result of relations with other matter, such as, the floor, the air and the light.

The idea of objects emerging in intra-actions connects to Barad's (2007) view of knowing, which is described as a part of the world making itself *intelligible* to another part. I will use "floating" to illustrate how I understand this idea. In the intra-action of floating, I see that the water and the floater become intelligible to each other as properties and phenomena emerge such as temperature, buoyancy, weight, wave patterns and sound. Without the mutual relation of the water and floater, the properties of the water would not emerge, not its coldness, buoyancy or viscosity nor the wave patterns. Neither would the weight, the floating/sinking ability, and the movements of the floater emerge without intra-actions. To think about knowing as parts of the world making themselves intelligible to each other means that science learning is something that emerges in mutual relations. For example, learning about several scientific concepts could emerge within the relations of the water and the floater (be it an item or a living being). Further this view of knowing implies that we cannot know from a distance, instead knowing and being are mutually implicated, and we are part of the material world that we continually endeavour to understand. As Barad (2003) puts it: “We do not obtain knowledge by standing outside the world; we know because ‘we’ are *of* the world” (p. 829).

Floating is a particularly interesting example since the themes of “water” and “floating and sinking” are popular parts of science activities in ECE settings in many parts of the world. Not surprisingly, water and buoyancy occur as central themes in several research examples from early years’ science. One example is the work of Christina Siry and Charles Max (2013), showing a series of situations where children had access to a big water tank and different items. Initially, the children’s investigations centred on how different items float and sink, but as the children noticed that crayons dissolved in water, the focus shifted to systematically investigating that phenomenon. Siry and Max portray the dissolving crayons as a critical event in this series of ECE activities. In their interpretation, in terms of steering the investigation, the agency is allocated to children and teachers. A more matter-oriented perspective would suggest that the material is a critical actor here, seeing that the intra-action of water and crayons is what directs the children’s attention to further investigate the phenomena of dissolving.

In all, there are movements in the research field of early years’ science education towards acknowledging children’s engagement with material as an important part of practice. However, to date the field has not embraced the idea of matter as an agentic part of preschool science activities. In an attempt to potentially change how we understand and organise science education in ECE (preschool), I will use two key ideas in the *agential realism* framework, namely, “agentic matter” and “intra-action”, to investigate: *How does matter matter to science learning possibilities in preschool pedagogy?* In addition, I seek to outline: *What are the implications for science teaching in preschool, from acknowledging matter as agentic and science learning as emerging in intra-actions?* My starting point is that power is crucial in science education in ECE, regarding power as regulations of what are possible, desirable and meaningful ways of acting in the ECE settings. Regulations of science learning are produced by the matter, children and teachers reciprocally. As this chapter explores implications for science teaching, I am particularly interested in the boundary-making practices of teachers restricting children’s intra-actions with different parts of the material world.

8.4 Reconsidering Empirical Data with Agentic Matter and Intelligible-Making in Mind

In this study, I revisit data from two of my previous research projects that concern science in preschool (Areljung, 2016; Sundberg et al., 2015). The data set produces different facets of preschool practice, since it consists of field notes, photos and audio and video recordings from practice, as well as recorded group discussions with teachers. In previous analyses of this data, we have studied conditions for science education, in ways that rendered matter inferior to humans and human dialogue. In one study, the material things were considered as tools used by humans

(Sundberg et al., 2015), and in the other study, the material things appeared as props in accounts from preschool practice (Areljung, 2016). This chapter is an attempt to flip that view and instead acknowledge matter as agentic and science learning as emerging in intra-actions. In seeking to uncover how matter matters to science learning in the particular sequences, I have been helped by asking: What if the particular matter or the particular intra-action had not been there? Specific examples of such questions in relation to the above-mentioned example of water and floater could be: What if there had not been water in that tank? What if there had been no floating? These questions help to cast light on the science learning that was possible thanks to the matter and the intra-actions that *were* in the sequences. In order to target the implications for science education, the analysis of possible science learning in the various situations has been accompanied by questions of power: What types of intra-actions are desirable, meaningful and accessible in preschool practice?

Despite my field notes being written before I had developed an interest in how matter matters to science education, some notes contained multiple references to material things. They were generated from situations involving 1–2-year-old children and were strikingly different from my field notes involving older children. The latter were dominated by my attempts to record spoken dialogue. In situations involving the older children, I can recall that I was not often looking at what was going on. Rather I was primarily looking down on my notepad, trying to capture as much of what the children and teachers were saying as possible. I was the typical adult that Lenz Taguchi (2012) describes, an adult too distracted by verbal language to notice matter-and-child intra-actions.

The empirical data presented in this chapter was selected because I judge that they are likely to resonate with the reader, as they represent situations common to early childhood education, and because they propose questions that inform science teaching. Recognising agentic matter as a prerequisite for intra-action, I start with a section where that idea is foregrounded, while the following examples delve into different aspects of science learning in intra-action.

8.5 Agentic Matter Dictating What Science Learning Is Possible in Preschool: The Ground Example

As mentioned above, one key aspect of *agential realism* is that matter is agentic, rather than passively waiting for humans to use it (Barad, 2003). Still we seldom recognise the agencies of material things, since we perceive their "work" as everyday normality (Taylor, 2013). Hultman (2011) argues that the pedagogical practice in preschool is built out of a myriad of non-human matter that dictates children's scope of action. Hultman also states, as mentioned earlier, that material things can "whisper, answer, demand and offer" (p. 77) and that children pose hypotheses *with* matter rather than *about* the matter. To think of matter making or giving suggestions may not be foreign for a scientist. When it comes to the scientific practices of posing hypotheses and searching for patterns, presumably many would agree that matter determines what is possible to ask and see. However, Barad (2007) posits that the intentionality, for example, of the asking and seeing, is not an exclusively human affair, but that matter is also an agentic factor.

To illustrate the importance of acknowledging matter as an agentic factor in preschool science, I have chosen a field note that concerns the ground:

> 25 November 2013, The Pea Preschool. One of the teachers tells me that it is dreary to be outdoors during this time of year, when the ground is hard and before the snow has arrived.

The teacher's comment about November being a dreary time of the year is something that I recognise from other preschool teachers that I have met. This teacher indicates that the dreariness is related to the ground being hard and snow-free. Why is that? Is it because of how the ground invites and responds? Thinking about the ground, I realise that one could distinguish so many different seasons from it and that different grounds matter to the scope of possible science learning. The preschool year in the north of Sweden, starting in August after the summer vacation, still has sun-heated ground with some plant growth. In September the ground is covered with leaves which could be moved around, for example, by raking leaves, putting them in piles and throwing them up in the air to rain down over you. October grounds are more damp, and in November and December, at least some days, the ground will be frozen and covered with a thin layer of snow crystals in the morning. In January and February, there is a layer of snow on the ground. This snow is sometimes relatively warm and possible to mould, sometimes it has a hard top layer, and sometimes it is light and feathery. When the snow melts in March and April, there is sometimes ice and sometimes "slush" on the ground. Then the ground gets wet again, with lots of water puddles and mud. In May plants spring from the ground, and in June it explodes in lush vegetation.

By discerning the state of the ground and the time of year, it becomes clear that the scope of possibilities for learning science varies in line with the changing matter. In sum, the ground is agentic on children's movements in different ways – encouraging and responding to the children's stepping, jumping, touching, pressing, rolling and sliding – at different times of the year. Hence it follows that over the year the ground provides children with possibilities to learn about different phenomena. For example, the sandpit is agentic, suggesting and determining what is possible to do (Duhn, 2012). Still, if we see a child playing in the sand, we usually do not see the sand as an actor. Hultman and Lenz Taguchi (2010) claim that our human-centred tradition leads our attention to the child's action and hinders us from seeing the role of the sand. These authors challenge the traditional way of seeing by proposing that the sand plays with the child as much as the child play with the sand.

In construction play, common to many ECE settings, building materials such as sand, mud and snow act differently on children depending on how cold and wet they are. In the northern part of the Northern Hemisphere, the August sand is warm and dry on the surface, and a few shovelfuls down it appears colder and wetter. The water holds the sand together, inviting children to build with it. In the "dreary" time of year that the Swedish preschool teacher referred to, the water has frozen which means the sand is solid and non-moveable and does not seem to engage children in long-lasting explorations.

How does the ground and time of year matter to children's potential learning about force and motion? For example, what type of ground makes sliding possible? Snow and ice, and perhaps mud and slippery wet leaves, yes, but a frozen and naked ground or ice covered with gravel has less potential or possibility for sliding. Here it is useful to consider Susanne Klaar's and Johan Öhman's (2012) account of how a child learns about friction by walking up and sliding down a hill, whose surface has patches of ice, grass and mud. The child adjusts her/his posture in relation to the surface by leaning forward when walking up a slippery hill, and when it is possible, she/he walks on the less slippery grass surfaces. When sliding down however, the child avoids the types of surfaces that she/he looked for when walking upwards. Further she/he seeks to gain speed by pushing her/his hands at an angle towards the ground. Reading this account from an agential realism perspective, I see that several important phenomena emerge in the ground-child relation: the incline and friction of the ground, the contact surface between the ground and child and the mass centre and posture of the child as well as the friction of their shoes and clothes. The ground thus contributes to producing children's embodied learning about forces and movement.

Acknowledging the ground as agentic means that the time of year becomes crucial to how one thinks of and organises science teaching. Certainly the scope of possible science learning differs between seasons of ice, snow, water puddles, lush vegetation, carpets of withered leaves and the "dreary" frozen November ground. The time of year pushes the science curriculum.

8.6 Learning Science as Matter and Children Make Themselves Intelligible to Each Other: The Bridge and Children Example

Another key aspect of *agential realism* is that all types of matter and living species always exist in relation to each other and that they come to be through mutual changes inside an intra-action (Barad, 2003). One example of such reciprocity is found in the above-mentioned example of a sandpit and a child, where Hultman and Lenz Taguchi (2010) argue that the sand and the child become together, since a change in one renders a change in the other. The following field note could also be read as "becoming together":

> 18 November 2013, The Magpie Preschool. I have accompanied two teachers and six 1–2-year-old children on their excursion to the forest. The forest area is rather open, and there is a layer of wet birch leaves on the ground. In the area, there is also a ditch with a wooden board placed across it, serving as a bridge. Some of the children tread carefully over the slippery bridge and after a while they jump on the bridge. The teacher asks: 'Can you feel it swinging?'. One of the children jumps again. The teacher says: 'Look, when the child behind you jumps, it swings'.

One important aspect of the matter in this example is its attraction to teachers and children. Though the ditch is long, their time is primarily spent near the wooden board (bridge). The board disrupts the place by being of another material than the rest of the forest ground and by being perpendicular to the ditch. It suggests being walked upon. When children carefully tread across the wooden board, they adjust their bodies by crouching down, with a lowered mass centre, and walking with small, slow steps. This is probably because the bridge is slippery and also because of its location a few decimetres above the ground. As the bridge and children become familiar with each other, the children's posture and steps become more confident. Thinking with *agential realism*, the bridge-child-child can be regarded as an intertwined system of bodies, where the bridge and the children make themselves intelligible to each other. Without the board, the children would not walk differently. The properties of their bodies emerge due to the height and slipperiness of the board. Without the children, the board would lie still and its property of slipperiness would not emerge. Another intra-action that can be discerned from my field notes is the bridge swinging and children jumping. Not all bridges would yield in this way, since this depends on the material and thickness of the board. Further the board would not yield without the children jumping. The children would not swing if the board was made from a less flexible material. And as the teacher highlights, the non-jumping child also swings when the yielding board and the other child's jumping render the whole system to swing. If a child was standing completely still (motionless) on the bridge, fewer aspects of the wooden board and the children would be made intelligible to each other. Much less would be learnt about the importance of surfaces, friction, bodies, mass centres and movements, if material and children did not intra-act through jumping and walking.

8.7 Matter and Matter Making Themselves Intelligible to Each Other: The Water, Colour and Paper Example

Another example from my research that can be read as science learning in intra-action comes with the following field note:

> 25 January 2013, The Snow Preschool. Five children aged 1-4 years and one of the teachers are involved in painting with water colour. There is a crumpled piece of paper in a bowl of water on the table. The teacher lifts the piece of paper out of the bowl and says that this is how paper gets when it is wet. Several of the children want to touch it. One child says that they should try what happens when there is water colour in the water, which they try, sensing the water-paper mix with their hands. The teacher takes out a dry and blank piece of paper and holds it next to a wet one, asking the children to look and listen while she shakes the papers. Afterwards a child crumples the dry, blank piece of paper and pushes it into the water.

This example accentuates that intra-action does not necessarily involve human bodies. In this case, the water, the paper and the water colour are made intelligible to each other through the intra-action of absorption and dissolution. These phenomena change the paper, the water and the stain, and through them their properties emerge. Still, seeing that the children dip their hands in the bowl of water, the children seem to want to be part of this paper-water-stain system. The teacher holds a wet, crumpled paper next to a dry paper, and the blankness, flatness and squareness of the latter paper could be understood as inviting change. Hence when the child crumples the paper and dips it into water immediately after the teacher-initiated sound comparison, this could be read as the child responding to the agency of the material.

8.8 Changing, Doing Again and Messy Material: The Water Hose Example

One key issue in the water-paper-stain-child example above is *change*, which seems to be an important part of children's relations with the material world. A couple of years ago, I collaborated with five teachers in a project aiming at developing a pedagogical model for science in preschool. During one of our project meetings, the teachers expressed that, in their experience, children – especially the youngest children – enjoy it when they can do things over and over again and when their actions have some notable impact on the material world. The teachers shared examples like turning the lights on or off or causing a sound by knocking on the table. Then the teachers and I discussed how these urges could be met in the preschool environment:

Teacher A: I am thinking about an activity wall for the youngest children, where they can push a button, or move something. These things that the youngest children can't help but get involved with. To cause a change in the shape of a sound or…

Teacher B: Turning something on and off, opening and closing a shutter…

During this discussion, I mentioned noticing that my 2-year-old nephew seemed very engaged when throwing stones into the sea and reeling in the water hose. One of the teachers responded:

Teacher A: That kind of thing, to reel out and in, is spot-on. Because then children are able to do it themselves, no one else has to restore it to the starting point, but the child can reel out and reel in, which are two different explorations somehow.

At that point in time, I had only scratched the surface of new materialism approaches to understanding science education. In retrospect, I can see that the teachers' comments about how young children appreciate change and repetition connect to Rautio's (2013) work on autotelic practices and the inherent reward for children from their repeated actions with material things. Further it resonates with Hultman's (2011) plea for teaching to embrace the important relations between children and matter in matter-child relations. As indicated in the excerpt, the teachers and I were engaged in finding materials that impact on children and that could be impacted on by children. What we were looking for were reversible intra-actions, which could be repeated over and over again, without causing harm to the child or to the physical surroundings, such as opening and closing a shutter. On the other hand, tearing all the leaves off a tree branch, or breaking the branches, would not be reversible since the leaves or branches could not be put back on the tree again, and further it could cause harm to the tree.

In the quoted dialogue, one of the teachers promoted the type of events that do not require an adult to "restore it to the starting point", which indicates that matter-and-child intra-actions should not necessitate constant intervention from adults. What does that idea imply in preschool settings? In the previous examples, matter such as sand, snow, mud, a slippery bridge and a water-stain-and-paper mix are intra-acting with children. Many of these experiences can be said to be "messy", a concept used by Elisabeth Nordin-Hultman (2004) to address the preschool materials that are wet, sticky, dirty, loud or easily spread. In her study of Swedish preschool settings, Nordin-Hultman notes that "messy" materials are often placed where they are inaccessible to children, for example, on high shelves. Her finding highlights that learning with matter is partly a question of access, as adults make children avoid some material things because of the risk of destroying the things and hurting themselves or of making a mess.

8.9 Painting the Sensation of Your Best Roll

One group of teachers that I have worked with framed science activities around the physics verb "rolling". This identification included activities such as rolling up and down and sidewards in a green field, rolling each other and teachers, recording the sound of rolling, painting with rolling items and photographing things that roll and do not roll (see Areljung 2016). On one occasion the children were encouraged to practise their best rolling in a room equipped with a sofa, a mattress and a carpet on the floor. One child prepared his rolling very thoroughly, moving slowly and straight over the mattress. Another child said she was performing a "jump-roll", and afterwards her hair stood out from her head due to static electricity. When the children were satisfied with their rolling, they showed it to the teacher, who took photographs and asked the children how their rolling felt. Next they were instructed to paint the sensation of their best rolling. One child said that he had painted his roll "in different colours next to each other" and that he wanted his roll "to be straight" (Fig. 8.1). The other child explained that the blue balls in the picture were her hair when she was rolling and the yellow part in the middle of the picture was "a little discomfort in the tummy" (Fig. 8.2).

In these activities, the children expressed and explored their experiences of rolling through moving, talking and painting. This rich repertoire of modes of expressions made way for children to extend their science learning and made visible dimensions of rolling that would otherwise go unnoticed for the teacher or, in this case, the researcher. The first picture, painted by the child who had rolled with his body as straight as possible, made me think of the contact between the body and the surface in each frozen moment of rolling. In one moment the mattress is in contact

Fig. 8.1 A roll that is straight and “next to each other”

Fig. 8.2 A roll including “a little discomfort in the tummy”

with one side of the body, from the head to feet, and in the next moment, this contact is between another part of the mattress and another head-to-feet part of the body. In that sense the mattress and child can be said to roll *together*, since the mattress pushes the child and the child pushes the mattress, which in a sense relates to Newton’s law of force and counterforce and in another sense to Barad’s idea of intra-action or Hultman's and Lenz Taguchi's (2010) sand playing with the child and child playing with the sand.

When it comes to the second painting, my interpretation is that the red square in the picture was the surface on which the child was rolling. The picture made me think about how the mattress, through the rolling, changes the child. It changes the sensation inside her body, "causing a little discomfort in the tummy", as she puts it. The rolling also makes her hair static, by electrical charges moving from her to the mattress. The children's paintings draw attention to rolling as a close relationship between matter and bodies. Seeing this from an *agential realist* view, the mattress is not a passive object, rather it becomes together with the child, and they change each other in the process of rolling. Further the child and the mattress are not viewed as separate entities but as bodies becoming in the rolling, in the contact with each other. The mattress and the child make themselves intelligible to each other in the rolling, and there emerges learning about rolling and the items that roll.

8.10 Implications for Science Education in Preschool

It has been strikingly rewarding to revisit my empirical data from preschool practice and think about them with *agential realism*, as it has foregrounded ways of learning science that I had not noticed in my previous work with the same data. I realise that one crucial argument for thinking of science education in terms of agentic matter and intra-action is that it supports activities that are important to children (Hultman, 2011; Rautio, 2013). Another argument, which I hope is conveyed through the above examples, is that thinking of science learning as intra-action helps to cast light on learning possibilities that would otherwise go unnoticed (for adults). In all, I contend that this chapter contributes important insights to science education in ECE, which I attempt to summarise below.

First, the above examples suggest that a teacher can think about a particular educational setting in terms of the science learning that is suggested by the matter in that setting. The example with the dreary, frozen November ground shows how the agentic matter impacts on the child's possibilities to act and make meaning of the world. Further it highlights the importance of time, as the ground drives the science curriculum, making different learning possible at different times of the year. The case with the swinging wooden bridge draws attention to how matter draws attention to itself, as the bridge was the place in the forest area where teachers and children spent most of their time. Further it illustrates how learning emerges in intra-actions, as the bridge and the children make themselves intelligible to each other, with their properties emerging through the walking and jumping. Without the bridge-children intra-action, the slipperiness and yielding of the bridge would not emerge, nor would the balance and mass centre of the children. The water-paper-colour example illustrates how different materials make themselves intelligible to each other. When there are several materials, more properties could emerge, compared to if there was only paper, or only water or only water colour. Altogether these examples imply the need to, as Lenz Taguchi (2011) argues, consider what kind of intra-actions might be possible in a certain time, space, room and structure of things.

Secondly, if we acknowledge that engaging bodily with matter is a central part of science learning, it becomes imperative that children have real access to engage with the material world with their bodies. The type of intra-actions that can be repeated over and over again (see Rautio, 2013) seem to be engaging especially for the youngest children; thus the provision of these experiences are crucial for teachers who want to support the youngest children's learning in science. Another crucial question is the children's access to modes of expression for extending their science learning. In the example with the paintings of "the best roll", the teacher addresses the bodily sensation of the mattress-child intra-action, and children tell how rolling changes their hair and how they feel in their tummy. In this case, verbal language is not privileged but combined with modes of expression such as body movement and painting.

Ultimately, if we agree that science learning emerges in intra-actions, we need to draw attention to, and disrupt, power relations that prevent children from learning in active engagements with the material world: Who may learn about forces and motion by actually engaging in the possibly messy intra-action of rolling down a hill?

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