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"It vapors up like this": Children Making Sense of Embodied Illustrations of Evaporation at a Swedish School

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ABSTRACT

Recent educational legislative acts and public debates in Sweden stress the importance of preschools providing playful and meaningful activities to enhance early experiences in environmental and natural science (e.g., Ministry of Education and Research, 2016). The present study investigates three 5–6 year old children making meaning of the concept of evaporation during an environmental water-theme. Illustrations, in which the participants own bodies were used to explain this concept were selected for further analysis and scrutinized with respect to Vygotsky's (1987) theories of how spontaneous and scientific concepts are linked together. The results tentatively suggest that the teacher's producing and the children's reproducing of embodied illustrations were beneficial for the children's emerging scientific sense making. By sticking to the play-based and theme-oriented preschool tradition the teacher avoided adopting a subject-oriented, school-like way to deal with an environmental phenomenon.

Keywords: preschool education; emerging environmental science; embodied illustrations; meaning-making; multi-modality

The importance of meetings with and enjoying emerging science is gaining terrain in contemporary preschool and prekindergarten education (see e.g.,Brenneman, 2011; Ministry of Education and Research, 2016). It has been argued that it is reasonable to assume that motivating *science* learning experiences in early years may result in an increase in students' engagement and achievement in science in the long run (see, e.g., [the US] National Research Council, 2005). In Sweden there is stronger emphasis than before on the importance of early experiences in school subjects like natural and environmental science both in recent educational legislative acts (e.g., Ministry of Education and Research, 2016) and in public debates, as an answer to a decreased interest in applying to technological and natural science tracks in, for instance, upper secondary education. This emphasis on early experiences increases the demands on the role of preschool for providing young children with opportunities to deal with common environmental and scientific concepts. The Swedish preschool curriculum (Ministry of Education and Research, 2016) states that the preschool should strive to ensure that children "develop their understanding of science and relationships in nature, as well as knowledge of plants, animals, and also simple chemical processes, and physical phenomena" and "their ability to distinguish, explore, document, put questions about and talk about science" (p. 10). However, the necessity of meaningful and playful activities based on the flow of the child's thoughts and ideas, has since long been stressed by both researchers and authorities (Asplund Carlsson & Pramling Samuelsson, 2008; Ministry of Education and Research 1998; Socialstyrelsen, 1987) although sometimes missed in science education by preschool teachers (Thulin, 2011, Larsson, 2016).

Early years environmental and natural science education in both pre- and primary schools typically uses explanatory illustrations such as pictures, models or animations as teaching aids to introduce, concretize, clarify, or repeat complex scientific phenomena (e.g., Helldén, Lindahl & Redfors, 2005). Such illustrations are often multi-modal in the sense that they involve more than one mode for presenting the information. Kress (1997) has described young children as being spontaneously multi-modal and using whatever is at hand, when creating, interacting or making meaning in a particular situation. Lemke (2000), on his part, has maintained that a wide range of multi-modal materials presupposes that children can handle visual, verbal and physical affordances at the same time, when grappling with the conceptual and factual content of a lesson. However, only accepting existing illustrations is not enough. Pupils need to engage themselves in using models as well as in making their own. In Lemke's (1990, p. 24) words, pupils have to talk science in their own ways and not only repeat explanations they have not made sense of.

When presenting illustrative educational aids, teachers and producers of study materials often seem to take for granted that children make sense of illustrations in an intended way. However, a number of scholars have claimed that the understanding of illustrations cannot be assumed to be universal or transparent, but rather is dependent on the person doing the interpretation, the situation as such, and the actual cultural context (e.g., Kress, 2003; Kress & van Leeuwen, 2006; Meira, 1998; Pintó & Ametller, 2002; Rogoff, 1990, 1995). An example from preschool environmental education has been presented by Ljung-Djärf, Åberg-Bengtsson, Ottosson and Beach (2015). These researchers found that the children in their investigation had great difficulties in interpreting some very commonly used pictorial symbols in an adequate way.

The study by Ljung-Djärf et. al. (2015) represents an area that still lacks research, in that it deals with illustrations used in natural science in preschools. A particularly neglected domain of research within this larger field is the use of embodied (i.e., bodily-based) illustrations and gestures in early science education. The present study, focusing on preschool children when handling and making meaning of embodied illustrations of evaporation, addresses this with the intention to contribute knowledge in an area where research is so far quite limited.

Previous research

A substantial body of research has been conducted about illustrations and how they are made sense of in educational settings. Most scholars in this field have conducted studies with older children or teenagers. In addition to research specifically directed towards preschool children, studies of older children and teenagers were also reviewed as they addressed areas of common interest for the present study. The review starts with the use of gestures in sense making processes. Some research on the use of images and equipment as teaching aids follows thereafter.

Crowder (1996, p. 174) explored how sixth-grade students used gestures when making sense of scientific phenomena and found that gestures may well "serve alongside verbal language as essential tools for sense making". She maintained that gestures not only assist in the construction of insights but also communicate scientific insights and assist in the construction of those insights. Wells (2008) is another researcher who has studied sixth-graders. In his case, the students were dealing with the concept of friction and the relationship between momentum and distance. Reporting on two boys, who used gestures as well as their own words when trying to report their findings, Wells stresses:

> It is notable that neither boy used the technical term 'momentum', although it had been used by the teacher and some students on several occasions in previous lessons. However, it seems clear that each was thinking with the aid of such a concept. (Wells 2008, p. 339)

Wells assumes that when the verbal language (or maybe the lack of certain words) sometimes holds up a conversation, other forms of communication can come handy.

A number of researchers have investigated the assumption that images in textbooks always support understanding. Some such studies indicate that this cannot be to be taken for granted (see e.g., Wennås Brante, 2014). Åberg-Bengtsson, Ljung-Djärf and Beach (2015) investigated 7–9-year-olds in Sweden, when trying to make sense of images in a reading material for early readers. Their results suggest that not even seemingly self-explanatory and relatively simple pictures may "by themselves without further explanations in text and guidance from teachers be interpreted in expected ways" (p. 17). This is in line with arguments by Ferlin (2014), who stresses the necessity for teachers to guide children in their interpretations of the increasing amount of illustrations in textbooks.

Although textbooks are not common in preschools, illustrations for explaining scientific phenomena are. There are, however, relatively few studies of meaning making of illustrations among young children. Ljung-Djärf, Åberg-Bengtsson, Ottosson, and Beach (2017) reported how 4–5-year-old preschool children had problems with assigning the intended meaning to seemingly transparent iconic symbols. Magnusson (2013) investigated preschool children when handling graphical symbols and concluded that the teacher has an important role in supporting children to develop symbolic skills. She argues that building on the children's previous experiences as well as giving them new challenges is important.

Fleer (2009) studied preschool children using different kinds of equipment during free-play activities. She noted that the first impression was that the children in their play seemed to learn about materials in a scientific way but that on closer analysis they were actually primarily acting on a spontaneous level concerning "what does the equipment do", rather than focusing on "materials and their properties" (p. 294). Fleer states that providing (more) materials without teacher input would therefore only promote everyday conceptual development. Leaning on Vygotsky, she argues that the playful context in her study "supported the interlacing of everyday concept formation and scientific concept formation" (p. 302) and provided conceptual spaces for the intertwining of the two. She stresses that this is only fruitful if teachers engage as mediators in these activities. This is similar to results presented by McClain (2016), who also points out the importance of teachers' guiding as well as their facilitating of children's collaborative scientific reasoning. In McClain's study, this was accomplished when the children were sharing their findings and hypotheses with peers and teachers, when exploring their environment in small groups.

<u>Previous research on children making sense of the concept of evaporation.</u> Research on environmental education in preschool, to a great extent, seems to deal with issues like sustainable development (e.g., Hedefalk, Almqvist & Östman, 2015; Ärleman-Hagsér, 2014), outdoor settings as learning environments (e.g., Ernst 2014; Ernst & Tornabene, 2012; Maynard & Waters, 2007; Moser & Martinsen, 2010) or young children's own ideas about their environment (e.g., Klaar & Öhman, 2014; Madden & Liang, 2016; McCain, 2016), with only a few studies being conducted on how particular environmental concepts are presented to and illustrated for young children. As already foreshadowed, this study investigates preschool children when exploring evaporation. However, I have not found much research that relates to pre-schoolers' encounters with this concept, but some investigations of primary school children are close enough to be of interest.

In longitudinal study Tytler and Peterson (2004) followed two Australian children from Kindergarten (age 5) to grade 3 (age 9) in order to trace their learning patterns, when dealing with evaporation. The findings showed a complexity in these patterns and dependence on the science learning-context as well as on the children's individual narrative context. According to the authors, motivational or affective state influenced the meaning making. For instance, one of the children was very concerned about not finding the right term for evaporation and constantly corrected her previous ideas, as it seemed, for "pleasing the adults", while another other child used narratives in a more self-confident way, to illustrate his ideas of the general evaporation-principles, which allowed him to more freely extend his ideas into new situations. The authors argue that the meaning making of a phenomenon is varying, depending on the situation as well as on the individuals.

In a study by Johnson (1998), 11–14-year-old students explored evaporation and condensation as a "change of state" (e.g., liquid turning into gas, as when there are bubbles in boiling water). Johnson maintains that although some of the children had noticed condensation before (e.g., when boiling water), very few of them had on their own given it any thought. When, in one part of the study, the pupils were left alone with their devises, they encountered great difficulties when trying to make sense of the concept.

In some studies pupils' dealing with evaporation comes in as a part of research on other hydrologic phenomena. For instance, Forbes, Zangori, and Schwarz (2015) investigated Grade 3 pupils' model-based explanations for the water cycle. They found, among other things, that the children in their models "emphasized water movement (…) more so than the forms of water (…) and water-Earth materials" (p. 911). Furthermore, the results revealed that, overall, in their representations, the children focused upon "the processes that change water from a liquid to a gas and gas to a liquid such as evaporation and condensation, rather than consider the forms as separate from the processes" (p. 911).

Sträng and Åberg-Bengtsson (2010) studied communication patterns between teachers and 8–10-year-old pupils talking about the water cycle in a follow up to a period of theme studies of water. Even though the focus of this study was not specifically on evaporation, it is evident that the children who came closest to accounting for the cycling of water, tended to use words like "it goes up and down". Typically though, the children did not use the term "evaporation", even though some of them talked about "steam".

Purpose of study

In my search for previous research on how environmental and natural scientific concepts are illustrated in preschool education, I found that studies of this kind seem to be extremely rare. Thus, in an attempt to contribute to this domain, the overall aim of the present study was to investigate, by the example of evaporation, how a teacher and a group of preschool children used embodied illustrations when talking and doing science.

Two questions were posed:

(1) How is the concept of evaporation bodily illustrated by the teacher? and
(2) How do the children handle and make meaning of the embodied illustrations?

This means that the focus was on how the concept of evaporation was embodied and communicated and on what seemed to be important in/for the children's sense-making and not on the concept per se.

Theoretical assumptions

This section deals with the theoretical perspectives that frame the analysis. First I present some Vygotskian and sociocultural views and thereafter multimodal approaches to meaning making.

In Vygotskian theory (e.g., Vygotsky 1987), language is central not only for communication, but also when trying to make sense of the world, for example, when forming scientific concepts. Vygotsky argued that such forming, is a process that takes place on two levels. Children initially use concepts in a spontaneous and functional way. They talk and act upon experiences on everyday basis, and natural phenomena are intuitively and spontaneously handled. These everyday concepts form the basis for the learning of scientific concepts. In educational settings and over time, everyday experiences pave the way for forming more abstract scientific concept. These two levels of concept formation are intertwined and also mutually dependent. Too strict a focus on the scientific level leads to the connection of the concepts with everyday world being lost. On the other hand, without gradually moving towards the scientific level, the spontaneous concepts might not be useful in other contexts than the present. Thus, in order to develop abstract reasoning, the children need various kinds of practical experiences. By participating in educational contexts dealing with environmental and natural scientific issues, children are allowed to discover and talk about scientific phenomena, not primarily for being taught particular pieces of factual knowledge, but for being offered various activities linking the everyday concepts to the scientific concepts.

Wells (2008) draws attention to the importance of offering various experiences of a concept beyond classroom learning, as a way to enhance scientific meaning-making. He claims that scientific concepts should not be regarded as something (mentally and) individually owned, but instead as cultural artifacts transforming in accordance with their *use* in different situations. He suggests that teachers' efforts should focus on selecting appropriate activities as well as on offering proper forms of guidance. This aligns with Vygotsky's (1987) claim that collaboration between teachers and children are crucial for the formation of concepts, in that the teacher "explains, informs, inquires, corrects, and forces the child himself to explain. All this work on concepts, the entire process of their formation, is worked out by the child in collaboration with the adult in instruction" (p. 215).

As pointed out above, language is the most central mediating tool (or in the words of Vygotsky "sign system") in Vygotskian theory. From a Vygotskian perspective the term language does not refer to spoken or written language only, but also to sign systems like algebraic symbols, diagrams, maps and other conventional signs (Vygotsky, 1981). *Gestures* are simply *"writing in the air"* (Vygotsky, 1978, p. 107).

Drawing on sociocultural perspectives assumes that illustrating as well as interpreting illustrations takes place in a historical, cultural and social context or, as stated by Wartofsky (1979), is something we do in that specific situation. Paraphrasing Wartofsky on models, it can be argued that nothing *is* an illustration of something, until we agree upon it to be one. Consequently, both the construction and the use of an illustration belong to a certain context and one particular illustration is not used or interpreted in the same way elsewhere (Engebretsen, 2012; Jewitt, 2008; Kress & van Leeuwen, 2006; Meira, 1998; Rogoff, 1990, 1995).

In multimodal perspectives, verbal language is considered as one mean among others in meaning making processes (Kress, 2010). It means regarding a non-verbal mode like an illustration as a full communicational resource, rather than a duplication of meanings already made in speech or writing (Kress, 2014). Further, a gesture can operate and bear meaning independent of other modes, for example, speech (Bezemer, 2014). Language then becomes but one part of an ensemble of modes (speech, gesture, text, sound, 3D, colour, and so on), which individuals need to choose between and orchestrate when construing and/or making sense of a situation (Jewitt, 2008; Kress, 2014; Kress & van Leeuwen, 2001; Kress et al., 2001; Lemke, 2000). Thus, the attention shifts focus from verbal language, towards the use and potentials of modes in a specific situation and further offers a "possibility of seeing meaning as embodied – as in our bodies" (Kress, 2010, p. 83). This implies that what can be handled with the help of, for instance, images in one situation is better handled with, for instance, gestures in another. In other words, modes have different meaning potentials both in relation to one another and to the context of which they are a part.

Kendon (1997) maintains that gestures are often regarded as something light-weighted, unimportant or positioned in the marginal. However, according to Kendon, gestures play an important role in symbol formation and communication practice by providing a culturally related meaning beyond speech. He states that even if it is difficult to draw a line between what is a gesture and what is not gestures can still "provide a visual representation of things that can be observed" (1997, p. 112). Kendon draws our attention to how gestures are shaped and influenced by historic, social and cultural traditions and circumstances. In other words, gestures (as well as other forms of communication) differ from one culture to another and we should not take for granted that a gesture is commonly understood.

Method

Three preschools participated in a large project dealing with embodied illustrations, which has resulted in several studies. In this section I present how I collected data at one of these preschools and conducted the analyses.

Collection of data

I collected the present data during a visit to a preschool with pronounced emphasis on environmental issues presented in hands-on and playful ways. The preschool was located outside a relatively large Swedish city and included four units about 70 children 1–6 years of age. One of these units was carrying out a yearlong theme of experiencing water.

I studied a group of children consisting of three 5–6-year-olds (Nora 6y, Kim 6y and Adéle 5y) and their teacher, when they investigated, in different ways, the phenomenon of evaporation in two consecutive outdoor sessions during the same day. The teacher had selected these children as they had shown a particular interest for a previously set up, closed-looped-system (described in the next section). I used a handheld camera to video-record the sessions. These recordings offered opportunities to capture not only the children's body movements, language, and facial expressions, but also their grappling with the illustrations in the context of the activity (e.g., Flewitt, 2006). In addition, I wrote down impressions from the sessions later the same day.

The studied activity was not a single isolated experiment, but one in the series of events relating to a yearlong environmental water-theme. During this theme the children dealt with water in different settings. Among other things they had explored different states of water. All activities were initiated in connection to genuine questions from the children such as: Why do water puddles disappear? What is a cloud? Do outdoor plants need to be watered?

Three weeks before the collection of the present data, an experiment with two plants had been launched, one secluded in a glass jar (a closed-looped-system) and one planted in an ordinary pot (Figure 1). The children had repeatedly during these weeks, been encouraged to observe the two plants to see what happened. In particular, the three girls in the present study had noticed and posed questions about the large number of water drops on the inside of the glass jar. To address their questions, the teacher had prepared a number of outdoor experiments, which were selected for the purpose of this study.

Figure 1: The potted plant and the closed-loop system as they were placed in a window

Analysis

A number of assumptions have guided the analysis. Firstly, illustrations are not universal and thus not necessarily transparent but construed, agreed upon and used in a specific context (e.g., Kendon, 1997; Kress, 2003; Kress & van Leeuwen, 2006; Meira, 1998; Pintó & Ametller 2002; Rogoff, 1990; 1995). Considering this, I analyzed the illustrations with respect to what modes were used well as to the situation as such. In this analysis I regarded both verbal and non-verbal interaction as important expressions of possible meaning making. Secondly, scientific concepts are formed through two dialectically related and thus equally important levels, namely the everyday or spontaneous and the scientific levels (Vygotsky, 1987). This drew attention to whether and, if so, how these levels were linked together in the studied activity.

In line with Jewitt (2012) and Flewitt (2006), I would argue that the analysis started already at the time of data collection, as doing a video recording as such involves a selection of interesting situations and so does the choice of what to document in field notes. All verbal interaction from the video recorded sessions was transcribed verbatim in a first phase and, thereafter, selected parts were complemented with body movements, gestures, gazes etc. I went through the video recordings as well as the transcripts a number of times, and highlighted passages relating to the aims and the theoretical framework of this study. This process resulted in the identification of a number of situations with different embodied illustrations of evaporation. In a next step, I analyzed these situations with respect to Vygotsky's suggestions of how concepts are formed by linking the spontaneous and the scientific levels of concepts together.

Results

In the analytic process, I identified three subgroups of situations, namely those with: illustrations related to the spontaneous level; illustrations that seemed to link the spontaneous and the scientific level; and illustrations used to bodily express and communicate scientific meaning. The results are presented below under three headings based on these three identified subgroups. The first heading, focuses upon how the concept of evaporation was explored, the second on how the term evaporation was introduced and linked to the children's experiences, whereas the third deals with how the children expressed and communicated meaning.

Exploring the concept of evaporation

The teacher started the outdoor activity by asking the children to carry out some tasks that were meant to illustrate the concept: to drink a glass of water, to use a spray bottle to create mist, and to put on a plastic glove (and leave it on throughout the whole activity). The children fulfilled these tasks willingly, even though the teacher neither connected the tasks to one another, nor related them to the concept in focus (evaporation). Instead they were told that these tasks "are part of the experiment" that will be explained later on. The teacher then turned the attention to the plant in the glass jar and the regularly potted plant, both of which she had brought out into the yard. She held the closed-loop system up while asking Adéle, Kim and Nora if they remembered what it was:

Excerpt 1:

TEACHER:	Do you remember this?
ADÉLE:	Yes, we locked that one up!
TEACHER:	We locked that one up. But why?
NORA:	'Cause it's not supposed to get any more water.
TEACHER:	And why is that? Isn't that kind of mean? 'Cause what do plants need to survive?
CHILDREN:	(In one voice) Water. And sun!
KIM:	And soil.
NORA:	Soil.
TEACHER:	Ok, but what does it [the plant] look like now?
ADÉLE:	Goooood!
TEACHER:	Is it still alive?
ADÉLE:	Yeeeees!
	[…]
KIM:	It's green.
TEACHER:	It's green. What would it look like if it was dead?
NORA:	It would have been wilted. Brown. Lying down sleeping.

On this occasion, the teacher did not use the term evaporation at all. Instead she posed questions about plants in general and about the plant in the jar and in the pot. She offered the children various ways to experience the concept by providing illustrations relating to water or moist (the secluded and potted plants, a spray-bottle, and plastic gloves) and encouraged them to explore and discover diversity. However, at this point the children did not get any further explanations to how and why there were differences between the plants.

After agreeing that the sealed plant did not show any signs of being "dead" even though no one had watered it since the closed-loop experiment started, the teacher continued the dialogue by asking why the plant in the jar had not dried out.

Excerpt 2:

TEACHER:	But how can this one [the plant in the jar] manage when it's trapped inside?
ADÉLE:	It has a lot of water.

KIM: It had a lot of water. In the soil.
NORA: Yeah the soil.
TEACHER: The soil? And it got a lot of water before we closed it in?
[Adéle nods her head.]
TEACHER: But why doesn't it dry out? This one [the ordinary plant], I've had to water it ten times since we planted it. And I still have to water it! But never this one [the plant in the jar]!
[The children giggle.]

The children's answers might indicate that they related the question to what they actually had done at the time when they closed up the plant (viz. "it had a lot of water"). None of the children seemed to have any ideas as to why the plant had not dried out now a couple of weeks later. For a further comparison, the teacher now encouraged the children to look at the moisture on the leaves (inside the glass jar) and to feel the dryness of the soil (in the ordinary plant pot).

Excerpt 3:
TEACHER: Can you put your finger in the soil to see if it feels wet?
[Adéle puts her finger in the potted-plant soil.]
ADÉLE: Dry!
TEACHER: A bit dry?
[Adéle nods her head.]
TEACHER: And what does *this one* look like [she holds the glass jar closer to the children].
ADÉLE: Wet!
TEACHER: Isn't this weird! This [the plant in pot] feels dry [Nora and Kim feels on a leaf of the potted plant] even though it had water ten times, but this [in the jar] looks wet without getting any water!
[The children smile at the teacher.]
KIM: Should we take a look then! [Taps on the jar lid] Inside, if there is water!
TEACHER: You have to look from the outside. I don't want to end that experiment. Does it seem to be any water in there?
[Nora takes the jar and holds it up. Nora and Kim look closely at the inside of the jar.]
NORA: YES! On the glass. There [tapping her finger on the jar lid].
KIM: YES! It's lying there. [Points at the top of the glass jar]. On the glass.

In all of the above examples the teacher guided the children to explore and discover the moisture on the inside of the glass jar. At this point she chose not to introduce them to the term evaporation. All three of them actively participated in the dialogue and were very eager to touch the soil and the leaves when investigating the water status of the potted plant. They also looked closely at the plant inside the jar, which they even suggested to open. However, none of them actually had any ideas as to *why* a sealed plant did not dry out. The teacher gave them hints on what to observe or explore but she did not serve them a full answer.

Linking experiences to the scientific term

After the initial, brief, exploring part of the activity, the teacher introduced the term "evaporation". Once again the plant in the jar was centered upon in the dialogue.

Excerpt 4:
TEACHER: If this one [in the jar] can live and it even becomes water in there, I think this is something I've read in a book. This is something called evaporation. Have you heard about evaporation?
CHILDREN: No, no, no.
TEACHER: Evaporation.
TEACHER: This one. [She raises the bottom of the jar up a bit.] Can you see, it has roots here at the bottom?
[The children nod their heads]

TEACHER: It [the plant] soaks up water with the roots here in the soil. And it goes up. Look here. In the leaves!

[The children look closely into the jar.]

TEACHER: It kind of squirts out like this from the leaves. [She sprays with the spray bottle towards Adéle, who giggles.]

TEACHER: So. When it soaks up water, it comes out through the leaves. It evaporates.

At this point the children were quietly listening to the teacher, when she talked about roots soaking up and leaves squirting out water. They were already familiar with the fact that plants need water and soak it up with the roots, but according to the children, the term “evaporation” (and as it seems also the fact that “water comes out of the leaves”) was new to them. In a next step, the teacher proceeded by initiating another experiment illustrating evaporation, in which she linked the familiar jar-illustration (that was usually kept indoor) to something that actually takes place outdoors “in nature” (water cycles; evaporation from plants and trees).

<u>Excerpt 5:</u>

[The teacher brings out a small, clear plastic-bag and a plastic clip.]

TEACHER: Let’s do this. If this plant [in the jar] can evaporate, do you think we should try if any other leaf say… over there, can do it? [Points to a nearby tree.]

CHILDREN: YES!

[The group runs to the tree.]

NORA: Or a flower? Can I take a leaf?

TEACHER: Let’s see. We’re gonna put it.

ADÉLE: [Holding up a single leaf] I’ve found one!

TEACHER: But we’re gonna wrap it around the whole branch.

[Adéle drops the leaf on the ground.]

TEACHER: [puts the bag around a branch/leaves and secludes it with a clip, *Figure 2.*]

[The children are standing close to the teacher while she’s wrapping the tree branch.]

TEACHER: But oh my goodness, poor thing! What will happen?

NORA: Eeeeporate..

TEACHER: Do you think there will be evaporation?

ADÉLE: Yes!

TEACHER: How’ll we see that?

ADÉLE: Wet. In the bag.

TEACHER: Ok. Wet in the bag. Cause it pff pff or? [Makes a squirting sound and finger movements.]

Figure 2: The plastic bag wrapped around the branch and leaves

The children were very eager to carry out the task and ran to the tree. However, thereafter it showed that the teacher had not been very clear about what she actually meant them to do. “Any other leaf … over there”, could of course be interpreted as *any* leaf (or flower) lying around. Referring to and picking up a single leave from the ground might indicate that there was, at least so far, no agreement on the link between the plant in the glass jar and the tree in front of them. However, after the plastic bag had been tied around the branch, both Adéle and Nora talked about evaporation (“eeeeporate”) and an expected outcome (“wet in the bag”). All three children showed an apparent interest in finding out what would happen inside the plastic bag.

At the end of the excerpt above, the teacher illustrated how water is evaporating from leaves by rapidly opening and closing her hands as if “squirting” water. In doing so, she relates to the children’s previous squirting with the spray bottle. In the next excerpt another bodily-based illustration is introduced, when the teacher tells the children a short story about raindrops.

<u>Excerpt 6:</u>

TEACHER:	And this other day, raindrops fell to the ground. And one sunny day, they disappeared. Do you know what happened?
NORA:	Nope!
TEACHER:	They [the drops] evaporated and went up, up. [She raises her hands up slowly, *Figure 3*]. Where do you think they went when they went up to the sky?
ADÉLE:	To the clouds!
TEACHER:	To the clouds! And what happens up there, when it gets too crowded?
ADÉLE:	It pours down!
TEACHER:	Go check the mirror where you sprayed some water earlier. Still a lot of water on it?
CHILDREN:	Noo!
TEACHER:	Is it less!? What do you think happened to the drops?!

[Nora, Kim and Adéle lift their hands silently, *Figure 4.*]

Figure 3: Teacher raising her hands up to illustrate water ascending (at the right)

Figure 4: The children raising their hands when using the same illustration of evaporation as their teacher

The teacher illustrated how water ascends from leaves and up into the air by slowly lifting her hands up (Figure 3). The children immediately copied this embodied illustration (Figure 4). This contrasts to the illustration in Excerpt 5, when the teacher in her reference to evaporation added a squirting finger movement – a gesture that the children did not imitate. Obviously, and in line with other observations in the present data, the girls here seem to have made an adequate meaning of the concept of evaporation, but adopted the embodied illustration with the lifted hands rather than the scientific term to express themselves.

At the beginning of the outdoor activity, the children had another opportunity to use their bodies for experiencing evaporation, when the teacher initiated the putting on of the plastic gloves. In the next episode the time has finally come for the children, to take the gloves off.

<u>Excerpt 7:</u>

TEACHER: Ok, if you take off your gloves now. Wait a minute, listen. Ok, so you drank some water [in the beginning of the activity] so there was water inside your bodies. What if, what if people also evaporate? What would it be like inside the gloves?
CHILDREN: Water!
TEACHER: Ok, try it out!
KIM: It's wet in mine!
NORA: This is wet too!
TEACHER: Is it wet inside?
KIM: Here it is totally wet!
TEACHER: So, when you drink water and wear a glove, you will like…evaporate, or?
[The children laugh.]

From a strict scientific perspective, it is, of course, incorrect to suggest that people (or plants) evaporate, as this term actually refers to the process by which water changes from liquid to gas or vapor. However, as the activity as such had started with the children's own questions about "disappearing" water puddles, among others, the teacher chose to focus on the phenomenon of evaporation and not, at this early stage, to mention the term transpiration (i.e., the process where water is carried through a plant or a human being) as well.

To sum up, the children were offered three different ways of experiencing evaporation: spraying water onto the mirror and into the air and seeing it fade away; drinking water, putting on plastic gloves and getting damp hands; tying a plastic bag around a branch of a tree and feeling the moisture inside the bag. During these sessions the teacher introduced the term "evaporation" and also bodily illustrated the concept by lifting her hands upwards. It seems reasonable to assume that these embodied ways of meeting the concept were important for the children's possibilities to make meaning and to talk about the concept. The next subsection supports this assumption.

Expressing and communicating meaning

The children's eagerness to participate in the activity, their willingness to come up with their own ideas and to listen to those of their group mates, might be regarded as parts of the meaning-making process.

In the present data, there are only two examples when the children actually tried to use the scientific term "evaporation" spontaneously, when talking about water ascending from the leaves. Instead all three children explained evaporation by slowly raising their hands, just as the teacher had frequently done, when illustrating her verbal explanations about how the water evaporated. Leaning on several indications from different parts of the activity, I dare suggest that these children had, nonetheless, made some meaning of the concept in that they used the teacher's embodied illustration when explaining and talking about it. The next example, taken from the summing up before lunch, is further strengthening my tentative suggestion.

<u>Excerpt 8:</u>

TEACHER: When we watered the plant, there were no water drops on the inside walls of the glass jar. Why are there drops there now? 'Cos we watered it down there right [point to the soil]?
ADÉLE: It has eeepored.
TEACHER: So where did the evaporating come from then?
ADÉLE: The roots.
TEACHER: The roots? In the bottom? But there's drops up here too [points to the top of the jar]. Does evaporation comes come from anywhere else?
ADÉLE: It, it vapors up like this [lifts her arms straight up].
TEACHER: It vapors up?
ADÉLE: [Nods her head.]
TEACHER: Ok. Adéle says like this, that she thinks that the water in [the glass jar] here comes from the roots, but there are no roots in this bag [wrapped around the tree branch]. So we will see if there is any evaporation […] coming from leaves as well.
NORA: Wiiii [lifts her hand straight up]

As can be notice, at one instance Adéle tried to use the term but she remembered it just vaguely and instead, some lines further down she used the expression "it vapors" and in addition lifted her arms in an upward gesture.

After lunch the researcher and the three children came to talk about the closed-loop system, which now was standing at the middle of a table. The researcher asked the children where it usually was placed.

<u>Excerpt 9:</u>

NORA: We put it in the window. So it can live anyway.
RESEARCHER: It [plant in glass jar] is still alive. But how?
NORA: But it had a lot of water and that, that thing we talked about before. Can't remember what it was called. What was it called, Kim?
KIM: Well … don't know!
ADÉLE: I don't remember either.
KIM: [Turns to the researcher] Can you?
RESEARCHER: Let's see. What are you thinking of? Explain, can you explain it to me?
NORA: Y'know this. With the roots. Soaking up water. From roots.
RESEARCHER: Soak up water, from the roots, eeh and what happens to the water, when?

NORA: [Interrupting eagerly] What's it called again?
KIM: It flies up like this [lifts her hands].
ADÉLE: Like this [lifts her hands].
NORA: Flies up and becomes a cloud [lifts her hands, Figure 5]
KIM: With that glove.
RESEARCHER: The glove? Are you thinking about evaporation?
CHILDREN: Yes!

Figure 5: The children talk about evaporation: "It flies up like this"

In the above example, the children were participating in a dialogue about evaporation. When talking about "roots soaking water", water that "flies up" (i.e., rises upwards) and "becomes clouds", they all used the embodied illustration (Figure 4) that the teacher had demonstrated in the previous outdoor activity (Figure 3) Kim also related this to the previous outdoor activity "with that glove" and used the hand-lifting illustration to explain the phenomenon. The children's eagerness to participate in the activity as well as their willingness to come up with own ideas and to listen those of their group mates, might be regarded as parts of the meaning-making process. Such eagerness was observed on several occasions during the studied sessions.

Later in the afternoon three hours after their first visit, the group were about to return to the tree with the plastic-wrapped branch. The teacher gathered them just outside the preschool and asked them about their ideas of what might have happened.

<u>Excerpt 10:</u>
TEACHER: But, what will it look like if the leaves evaporated. What would it look like in the bag?
KIM: [Lifts her hands up.]
NORA: Then it'll be wet!
ADÉLE: Wet!
[The children run off to the tree. They watch the plastic bag closely.]
ADÉLE: [Shouting] There has been evaporation!!

KIM: Yes!!
NORA: Yeeeh! It's foggy in here [points to the bag].
ADÉLE: Foggy, foggy!
TEACHER: Foggy foggy. So the leaves did squirt some water then?
ADÉLE: Yeah!
[…]

Kim used the embodied illustration of evaporation (lifting her hands straight up) to express her idea of evaporation. Nora and Adéle described the outcome of the experiment verbally and declared that is was "wet" in the bag. However, Adéle also once used the term "evaporation".

At the end of the afternoon session, the teacher summed up the activity, by linking Adéle's initial suggestion about evaporation ("it comes from roots") to the outcome of their tree-branch experiment.

Excerpt 11:
TEACHER: So this means there was evaporation. Good. And you Adéle said that it comes from roots and now we say both roots and leaves, right?
ADÉLE: [Nods her head.]
TEACHER: I think it's time you all feel inside [the plastic bag] with your hands!
[The children put their hands inside the bag, *Figure* 6.]
CHILDREN: [Screaming] Oiiiiiii!
TEACHER: So it's true? Is this worse than inside your plastic gloves?
KIM and ADÉLE: YES!

Figure 6: The children put their hands in the bag (to feel the moisture inside)

Throughout this last part of the activity, the children jumped around giggling. Especially the moisture inside the plastic bag seemed particularly exciting (Figure 5). Their joy of being a part of this experience was evident.

Discussion

The aim of the present piece of research was to investigate, by the example of evaporation, how a teacher and a group of preschool children used embodied illustrations when talking and doing science. In order to explore this issue an empirical study was conducted in a preschool setting, when a preschool teacher and three 5–6-year-old children were observed and video-recorded in situ, when exploring evaporation during an environmental theme about water.

Two research questions were posed. The first of them concerned how the teacher illustrated the concept of evaporation. It showed that the teacher had prepared three bodily-based experiments for the children to carry out: to feel and observe the moisture when spray bottle was used; to put on a plastic glove and feel the moisture forming inside; and to tie a plastic bag around a small branch and after two hours feel the moisture on the leaves and inside the bag. In addition, she spontaneously used illustrative gestures.

The teacher first presented the concept of evaporation to be explored in an everyday and playful way, but this early she did not introduce the children to the very term “evaporation”. In this part of the activity, the she also asked why the plant in the closed-loop system from a previous theme-related experiment did not dry out. At this point the children seemed to relate to what they had done when they had sealed the plant into the jar. The reply “it had a lot of water” might be interpreted as a result from interacting directly with the every-day world, where spontaneous ideas (and concepts) are being formed (see, e.g., Fleer 2009). When the teacher shortly thereafter introduced the term “evaporation”, all three children said that they had never heard it before. At their age, this word is probably seldom used in their every-day life (unlike other concepts, e.g., “temperature”). From a Vygotskian (1987) perspective, the embodied illustrations present mainly related to the spontaneous level, but in the ways the children used them, they also seemed to link the spontaneous and the scientific levels together. This will be further discussed below.

The second research question dealt with how the children handled and made meaning of the embodied illustrations. From the present results, it may tentatively be concluded that the investigated activity, in which the teacher produced and the children reproduced embodied illustrations to handle the concept, was beneficial for the children’s emerging science. Even though the children, as a rule, did not use or tried to use the term “evaporation” spontaneously, their gestures indicated that they still seemed to have made some meaning of the phenomenon. It appears plausible that their bodily experiences of the concept had also contributed to their readiness to talk science. The teacher’s role in this linking of the everyday and scientific levels was crucial, which is in line with Vygotsky’s (1987) theories. By giving the children playful and varying every-day tasks and questions in combination with a fair amount of time to explore, experience, and communicate through embodied illustrations, she created a conceptual space in which a foundation for the formation of the scientific concept of evaporation was offered (see also, Fleer, 2009).

Offering children embodied illustrations, as was the case in the present study, could be one way of inviting them to participate in conversations about complicated processes without being forced to use specific terms or to answer for certain facts. Lemke (1990, p. 24) has stated that the children’s “talking science” in their own ways as well as doing science, is important for their making of meaning. This would suggest that, in an emerging science context, it is advisable to allow children to freely explore concepts without the limitations of being forced to apply a scientific vocabulary or verbally checked for achievement afterwards. We must keep in mind that we have to do with very young children meeting with complicated scientific phenomenon that will be further elaborated in forthcoming education. In the present study, the children did not try to explain evaporation only in words, but rather “talked science” by using their bodies as well (cf. Crowder, 1996). This resembles the observation in Wells’ (2008) study, when two somewhat older boys dealing with momentum seemed to be thinking with the aid of the concept in question, even though they did not use the technical term.

In line with Wartofsky (1979) on representations, I have suggested previously that nothing is an illustration before we agree upon it to be one. This means that the use of particular embodied illustrations in the present study is related to the particular preschool situation in which they were created. Stated differently, embodied illustrations (as well as other illustrations) are not to be regarded as universal or transparent, but understandable only when used and interpreted in their historic, social and cultural context (e.g., Engebretsen, 2012; Jewitt, 2008; Kress & van Leeuwen, 2006; Meira, 1998; Rogoff, 1990, 1995). Someone outside this particular group of children and their teacher might not, for instance, have understood arms lifted towards the sky as an expression for evaporation.

The studied activity initially emanated from children noticing and wondering about the water on the inside of the glass jar in the closed-loop system. This system, in its turn, was made when the children asked about clouds, rain and if outdoor plants needed to be watered. Based on the children's spontaneous curiosity, the preschool teacher thus initiated the experiments and guided the children towards a new scientific concept. In doing so, she focused on what there was to observe and experience, and carefully introduced the term "evaporation" but did not insist upon that the children themselves should use the word. By building on embodied illustrations during the prepared activity, she stuck to the play-based and theme-oriented, preschool tradition, where teachers are free to work in multi-subject and multi-modal ways. Thus, she avoided falling into the trap of adopting a subject-oriented and school-like way to deal with an environmental phenomenon.

The results presented in this article emanate from a small study with only three children and their teacher exploring the concept of evaporation. Thus, far-reaching conclusions should not be drawn. The study still highlights the role that embodied illustrations may play, when introducing emerging scientific concepts in preschool. I have previously identified a shortage of research both on illustrations and, to a large extent, also on how the concept of evaporation is handled in environmental education in preschool. Hopefully, this article has, in spite of its limitations contributed to our knowledge within a relatively neglected field of research.

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