Chapter 10
Learning to 'Read' and Produce Graphical Representations in Science

Niklas Pramling

Abstract In this chapter figurative (metaphorical and similar) speech is discussed in the context of the distinction between "as is" and "as if" statements. Representational practices and modeling phenomena are all examples of semiotic mediation. Since learning is understood as the appropriation of cultural tools that come to mediate the learner's engagement with the world, how teachers introduce children to, and support them in appropriating such tools, is the focus of attention of this chapter. It is argued that what others have experienced can be made into cultural tools. That is, these cultural tools are represented as artefacts, such as speech, writing, images, drawings, pictures and recordings. Throughout history, human experience and knowing have collectively accumulated in the form of cultural tools and artefacts. Empirical data on the topic of teaching about the human body taken from a preschool is presented in order to examine how teachers allow or even encourage children to 'take' or use representation tools (e.g. drawing) and metaphorical speech during conceptual play.

Keywords Human body • Drawing • Metaphorical speech • Representations

10.1 Introduction

Figurative (metaphorical and similar) speech, the distinction between as is and as if, representational practices, and modeling phenomena are all examples of semiotic mediation (Wells, 2007; Wertsch, 2007), that is, the fact that we do not have immediate access to the world but through the cultural tools that we have appropriated or are in the midst of appropriating. As was introduced in Chapter 1, Mediation was a revolutionary idea in Vygotsky (1987, 1997, 1998) and basic to a cultural-historical perspective on human learning and development. How this issue of mediation comes into play in teacher-child interaction in early childhood education, what it entails for children's development and teachers' role in this development are the themes of this chapter, focusing on representational practices in early childhood science learning. Since learning is understood as the appropriation of cultural tools that come to mediate the learner's engagement with the world, how teachers introduce children to, and support them in appropriating, such tools are key interests of this chapter.

M. Fleer, N. Pramling, *A Cultural-Historical Study of Children Learning Science,*
Cultural Studies of Science Education 11, DOI 10.1007/978-94-017-9370-4_10

One important feature of a cultural-historical perspective on human learning and development is the notion of tools (Daniels, 2005; Kozulin, 1998; Säljö, 2005; Tomasello, 1999; Vygotsky, 1978). Throughout history people have developed tools that allow us to externalise knowing, make it public and give it permanence over situations and generations. These tools come to mediate learner's engagement in the activities where they are used. We learn about the world in a 'roundabout' way, to use Vygotsky's metaphor (Fleer, 2009; Vygotsky, 1991). This means, among other things, that we do not each and every one have to experience something in order to know something. What others have experienced can be made into cultural tools, that is, be represented in artefacts such as speech, writing, images, drawings, pictures and recordings. Throughout history, human experience and knowing are collectively accumulated in the form of cultural tools, artefacts. This has important implications for educational practices. Learning to great extent becomes a question of appropriating (taking over, learning to produce and 'read') various kinds of representations. Some examples would be texts (literature), diagrams and models in science education. A particular kind of representation is metaphorical speech, in saying that one thing is another thing that it cannot in a strict sense be. This kind of speech shares with a visual representation (e.g., a schematic drawing of the inside of the human body) that it is 'tricky'. The learner/reader must learn how to 'take' the representation (i.e., in what sense is what is spoken about [like] this representation). Clarifying this matter could be seen as a re-contextualisation (van Oers, 1998), of relating previous experience and language to something novel. Where the representation or metaphorical speech 'takes' the child will likely be contingent upon how it is responded to and managed by the teacher. Does the teacher, for example, allow (or even encourage) the child to 'take' the representation/metaphorical speech in one or the other direction (conceptual play)?

In order to investigate and shed some light on these issues, in this chapter, we will analyze empirical data from early childhood education (a Swedish preschool). The empirical data for the present analysis comes from a theme on the human body, conducted over three consecutive arranged learning situations in a preschool with children. A small group of children, varying between the three occasions but at most six children and their teacher participate in the activities. The activities take place once a week for three weeks in a row. During these occasions, they look at visual representations in books, make drawings and speak about these and the phenomena they represent. Hence, how the teacher and children manage matters of representation, that is semiotic mediation, is analyzed in this chapter.

10.2 Previous Research on Children's Drawings in Science Class

There is quite an extensive research literature on children's understanding of the human body and its organs (e.g., Carey, 1985; Cuthbert, 2000; Guichard, 1995; Óskarsdóttir, 2006; Tunnicliffe & Reiss, 1999). This literature is often based on

constructivist theory and reports what is referred to as children's 'misconceptions' and at what ages children develop certain insights. However, we will not review this literature here, for several reasons (for overviews, see STCSE database). First, taking a very different theoretical perspective, what children say and do are interpreted differently (Pramling, 2006b) and the kind of data that is used also tend to differ. In addition, from our theoretical position, it is highly problematic to conceive of children's reasoning as being 'misconceptions'. Rather, they make sense of the task as they perceive it and their ways of reasoning is highly contingent on the nature of producing data, including how questions and tasks are communicatively framed (Aronsson & Hundeide, 2002; Goffman, 1974; Säljö & Wyndhamn, 1993). All these matters are elaborated upon in the present book (see particularly Chap. 7), and in this chapter. Finally, the issue we thematise in this chapter is not how children understand the human body and how that understanding changes with age, but theoretical issues having to do with representation and the coordination of perspectives between a teacher and a child. We will therefore primarily refer to a different body of literature. Still, we will here overview studies where children have been asked to make drawings of the human body (and then talk about these drawings).

In their study of drawing during science activity in primary school, Hayes, Symington, and Martin (1994) suggest that there are several reasons for letting children make drawings during science activities. First, the common observation that (most) children like to draw is in itself a reason to let them do it, since, Hayes et al. write, "The enjoyment they derive is likely to be important in providing the motivation for engaging in similar activities in the future" (p. 265). While being sympathetic to the point made, we may add that "similar activities" from the child's point of view may be drawing rather than science activities. Hayes et al. add another reason for including drawing activities in science class. They divide this reason in two groups. The first, referred to as 'objective purposes' denotes the expectation that the activity will result in children developing certain abilities, such as observing or understanding phenomena investigated. The second reason for including drawing, referred to as 'process purposes', denotes the idea that the activity will develop in the children other skills such as communication skills as well as keeping the teacher informed about how the children think about phenomena. While children's drawings can be informative as to how they understand something, there are many additional issues to keep in mind. For example, in contrast to earlier psychological theorizing on children's drawings, these are no longer considered 'windows into the child's thinking or understanding' in any clear-cut manner (Bendroth Karlsson, 1996). There are several reasons for this, including the fact that drawing for children to a large extent is a social activity where they feed off each other (Änggård, 2005) and that representations – whether in the form of drawing, writing or other modality (Kress, 1997, 2003) – never stand in a simple one-to-one correspondence with what they refer to (Pramling, 2006a). In fact, the latter issue of the dynamic tension and potential developmental relationship between representation and its reference lies at the heart of what will be analysed as the participants' concern in this chapter.

Osbourne, Wadsworth, and Black (1992), among many different data sets, used children's drawings to investigate their understanding. One finding was that the

youngest children (who were 5–6-years old) drew organs that they could easily discern such as the heart (through its beats) and the bones. As found in the study,

> the predominant organs named by all children were the heart, bones, stomach and brain. The study also revealed that many children were not aware of the correct size or the location of the organs which is probably because the internal organs are not visible or touchable and therefore it is difficult for the child to develop knowledge of their size and correct location. Organs that are not part of everyday language like kidneys, liver, intestines and even lungs were usually excluded by the children although most of the children knew that we need air to live but very few were able to locate the lungs on a drawing of the human body. (Osbourne et al., 1992, p. 37)

This finding also, from our point of view, implies the importance of attending to issues such as representation in speech, including how tasks are given, questions are posed, terms explained, and perspectives are coordinated.

In a study of almost 600 pupils from 11 different countries, Reiss et al. (2002) gave pupils a blank piece of paper and asked them to "draw what they thought was inside themselves" (p. 58). The pupils were 7 and 15 years old, respectively. The overarching question for the study was whether the pupils' knowledge of their insides is "dependent on their culture" (p. 58). The drawings were graded by the researchers according to a predetermined scale "where the criterion was anatomical accuracy" (p. 58). If taking a cultural-historical perspective, there is no neutral way of giving a task, and therefore we cannot presume that all the children intended to make anatomically accurate drawings. There are always the issues of how a task is given and taken, and it is well known that subtle differences in how tasks are given are of decisive importance to how people act in response to these (Aronsson & Hundeide, 2002; Donaldson, 1978; Hundeide, 1977). The task was given to the pupils in the following words: "I would like each of you to do a drawing of what you think is inside yourself" (p. 59). If a child was to say that he or she could not draw, the researchers in the various countries were instructed to say that he or she need "not to worry and that we are interested in what they think is inside themselves not in whether they can draw well" (p. 59). Two things are noteworthy with the last comment. First, that the drawings are seen as more or less unproblematic pictures of children's thinking and second, that despite this instruction, the drawings were subsequently in fact analysed in terms of "anatomical accuracy", that is, how well they represented the inside of the body. However, the oversimplified stance taken towards the drawings are noted by the researchers themselves. For example, they reproduce a drawing made by a Chinese student containing not only labels on the drawing such as 'cell', 'blood' and 'heart' but also 'future' and 'money'. As for the cultural dependency of the children's understanding, only minor examples are given, and no systematic analysis and result in this regard is reported in the study.

It should be remembered that the children of the present chapter are far younger than the children covered in the research studies here briefly reviewed. Also, the situation of drawing was very different to the task-like nature of previous studies. What we follow and analyse is the unfolding nature of how a teacher and children communicate about and through the drawings the children make, particularly regarding issues concerning how to produce and 'read' representations.

10.3 Empirical Study

10.3.1 Introducing the Theme

The first event is introduced by the teacher and the children sitting in a circle on the floor. The teacher reminds the children of something they had found in a cupboard another day:

```
Teacher:     We found small eggs, in a bag, so we mixed them
             together with a little water. So we put the eggs
             in the water. [---]
Teacher:     Do you remember what type of eggs they were?
Children:    No
Teacher:     What were they going to grow into?
One child:   Shrimps.
Teacher:     Shrimps, yes. You can hardly see them, they are
             so small. [Takes out a glass bowl and shows the
             children]. You can just see that it is a little
             dusty in there. Can you see that?

[The children look carefully into the bowl]

Teacher:     How small are they?
One child:   I can't see the eggs.
Teacher:     No, they're so small. You can look one at a time.
             Do you see? That it is, it's a little cloudy,
             like tiny grains of sand.

[The children get to look in the bowl, one by one]

August:      I saw the eggs.
Richard:     I can see loads of brown peas.
Teacher:     Yes, and I have actually put some of these eggs
             in the microscope over there. Although they will
             be big on the screen.
```

Supporting the children in remembering what event she refers to, the children recall that the eggs would become shrimps. Interesting to note in this initial excerpt from the activity is also how the teacher and children verbalize what they see. Looking at the eggs, the teacher suggests that the eggs are hardly perceivable, `You can just see that it is a little dusty in there`. Words like `just a little` and `it is, it's a little cloudy, like tiny grains of sand` are forms of markers that hint at the difficulty of seeing (visually as well as conceiving) something and that therefore a simile is used. In response to this suggestion, Richard says that `I can see loads of brown peas`, that is, he describes what he sees in familiar terms from another domain. The children then get to look at the eggs under the microscope.

In the evolving conversation between the teacher and the child, babies are introduced. Speaking about a child's mother having a large belly this transition in the conversation is made.

Teacher: A little baby. And we will see what happens with the little thing, that's inside there. […] may stand here. But I also thought that we should talk about what we look like inside. Because you are growing all the time, aren't you? Do you think that you will grow bigger than you are now?
Eva: I'm really big, this big [stretches up her hands].
Teacher: Do you think you are going to get bigger?
Eva: [Nods]
Teacher: We will look at what we have inside our body.
Dennis: Yes.

Hence, during the conversation around the eggs and the microscope, the talk goes from shrimp eggs to human fetuses to how humans look on the inside. This is a kind of analogical reasoning that leads to the theme to be worked on: the (inside of the) human body.

10.3.2 Representing the Human Body in a Drawing

The teacher now takes out a large sheet of paper and crayons and says that they shall draw a body, Just like you look. Then you have to think, how do we look? What do we have up here? To this several children reply, Head. The teacher confirms the children's suggestions and continuing drawing the outline of a human body on the paper, asks the children, And what do we have below the head? and, What's this (showing on her body)? The children respond, shoulders, throat, stomach, chest, arms, hand, bottoms, legs…

Teacher: Legs go there, yes. [draws] Now we are looking at this body from in front, so that we can't actually see the bottom. We can do this [draws a little around by the hips] so that we know that the bottom is behind here. Then we have the legs.

This explication from the teacher introduces an important issue for our present concerns, that is, the issue of representation and how to represent what one knows is there but cannot be seen from a certain point of view. Another important issue that comes into play when representing something is aesthetic preferences. When drawing the eyes of the person on the paper, Polly suggests they be pink. Drawings in preschool often take on a kind of hybrid form where issues of representing something ('accurately'), on the one hand, are intertwined with the issue of drawing something nice, beautiful or expressive, on the other (cf. Bendroth Karlsson, 1996; Kress, 1997; Pramling & Pramling Samuelsson, 2011). The issue of the aesthetics of the drawing of the human body will recur throughout the activities. Central to representing something is of course also what the representation is a representation of. When coming to drawing the face, the teacher asks, where is the chin on the man? This question prompts Dennis to respond, it's not a man,

it's a girl. This suggestion may be due to the fact that earlier in the activity, they had spoken about and drawn breasts on the figure. One of many examples of the issues of aesthetics and referent of the representation coming into play is the following exchange when one child says He is fine and the teacher responds, Really fine, or is it a she? One doesn't really know huh?

Having drawn the outline (contours) of a body, the theme of the *inside* of the human body is introduced by the teacher in the following way:

Teacher:	Now I have a question, actually, before we finish. What is behind our eyes, cheeks and nose [points to her own face]? What do we have inside?
Richard:	Blood!
Teacher:	There is blood inside, yes. I'm going to write up what you say now. We have blood, what else do we have inside our head?
One child:	I know! Our brain!
Teacher:	Our brain, yes. What do we use our brain for?
August:	To suck up the blood.
Teacher:	[Writes on the paper] Blood, we'll write that here. And brain…to suck up the blood, we'll write that there.
August:	Yes.

Another mode of representing is thus introduces along with the new focus on the inside of the human body, through text (words and instructive comments). This means that the representation becomes more complex. In difference to outlining a human body, for example, following with a pen the extension of the fingers on one's hands, words do not stand in such a simple and iconic relationship to what is represented.

Connecting to the issue of blood, the teacher directs the children's attention to a visible feature:

Teacher:	Have you seen this? Look here! Look at me, at my arms [shows blood vessels on her hands and arms]. Do you know what this is? This blue thing. [Polly continues to try to say something about it sucking blood, but Helen continues to point and ask. Polly becomes quiet and shakes her head.] It's actually a little tube, you could say, so that the blood can travel inside. This blood is on its way back to my heart. What is the blood doing here?
Polly:	And Cator actually has a heart.
Teacher:	Yes, he has. That's in the Brothers Lionheart.

In explaining what it is they see, the teacher uses a metaphor and a marker, It's actually a little tube, you could say. Words like you could say and actually, as paradoxical as the latter may seem, are frequently used to signal that something is being spoken about in more familiar but not entirely correct words, that is, that the utterance is figurative rather than literal (Goatly, 1997). One of the children responds to the teacher's question by relating to a character in a fictional story. The children are now weary, after having worked on the human body for half an hour and the activity ends.

10.3.3 The Parts and Functions of the Human Body and How It Is and Can Be Represented in Drawings

When the group of children a week later (this time only three of the six children from the first event is present, and their teacher) meet in the 'nature group', one of the children, August, immediately connects to last week's topic, There was also skeleton (points at the outlined person on the large paper). The children suggest more features of the body, such as hair and nose and that you blink with the eyes. The teacher connects and expands:

Teacher:	Yes, we blink with our eyes. What else do we do with our eyes?
[Music and talk in the background makes it difficult to hear]	
Malin:	Have medicine in them.
Teacher:	What?
Malin:	Have medicine in them.
Teacher:	Yes, we can have medicine in our eyes if they are poorly, quite right. But if we close our eyes, can we see anything then?
Several children:	No.
Teacher:	And if we open our eyes, we do we do then?
Children:	See!
Teacher:	See, yes. We use our eyes to see with. Don't we? To see what is happening. Then we have these things over our eyes [points to her own eyebrows].

The teacher thus introduces the issue of the functioning of different body parts, that is, what we do with the eyes. The teacher confirms the child's uptake, that we can take medication in the eyes, but then introduces another issue, But if we close our eyes, can we see anything then? Continuing along these lines, the conversation continues:

Teacher:	What do we do with our nose?
Malin:	Holes.
Richard:	Smell with.
Teacher:	We have it to smell with, yes. And we have little holes in our nose as well, yes, we have two little holes in it as well. Mm. And then, can we do anything else with our nose. Do you know what it is called when we do this? [Shows how she is breathing in]
Richard:	Bogies!
Teacher:	Yes, you have some bogies in your nose, yes, which makes it a little for you difficult to do it. We breathe with our nose. And we also breathe with our mouth. What happens when we breathe? Do you know?
August:	Are we going to do the skeleton?
Teacher:	Yes, we are going to do the skeleton. What happens when we breathe? We take in a lot of air, like this [breathes in deeply]. What happens then? Where does the air go?

Richard: Away!
Teacher: It disappears somewhere down here in the body, doesn't it. If you hold here. [Shows on August] And you breathe in. It becomes so big there. And then you breathe out. There is a book here. You can see what it looks like inside your body. This is an old book I found. [leafs through the book]. Then we will see what happens. Here we have what August was talking about [points to the picture]
August: The skeleton.
Teacher: Here is the skeleton, yes. What is the skeleton made of, then? Do you know? Is it hard or soft?
Children: Hard.
Teacher: It is hard, yes.

The children's responses are relevant and the teacher confirms them, but she also redirects their attention towards other aspects of the nose (or earlier the eyes) from smelling to breathing. After giving a first explanation of breathing, the teacher picks up a book with drawn illustrations of the inside of the human body, including the skeleton which seems to particularly attract August's interest. The teacher and the children look at the illustrations and speak about what they see:

Teacher: We have a lot of skeleton here, don't we. [Shows August] Throughout our body. Now we will see if we can find out about… what we were talking about before. Can you see that here is the head? And you said that there is a brain and that we suck up blood with it. And here is the brain, actually [points in the book]. Now the brain probably isn't blue. They have drawn it with lots of strange colours. Do you know, what colour do you think the brain is inside?
Malin: Blue.
Teacher: You think it is blue, OK. What do you think, August?
August: Green.
Teacher: Green, you think? What colour do you think the brain is Richard?
Richard: Red!
Teacher: Red, you think? Why do you think it is that colour?. Why do you think it is green [turns to August]?
August: I think because it is green here [points to the picture].
Teacher: Mm, on the picture. This picture is fooling us, actually, because the brain is not really green or blue. Why do you think the brain is red, then? [Asks Richard]
Richard: It is inside the body.
Teacher: It is inside the body? Mm.
Teacher: It's probably a little more reddish-brown, yes. And that is actually true, because it is actually. You also said that there is blood in there. Didn't you? And that's also true.
Richard: And it gets, there are bumps as well.
Teacher: Yes, there are bumps. What is a bump?

Richard: [Points to his head and says something inaudible]
Teacher: It's actually if you knock yourself, you get blood inside here. Then it becomes a bump. Then it turns blue.

This sequence is of particular interest to the issue of representation. The relationship between the brain and blood as introduced earlier during the first event is now returned to. In addition, as triggered by the illustration in the book, the issue of what color the brain is, has been raised. In the drawing it is blue. However, as the teacher cautions the children, Now the brain probably isn't blue. They have drawn it with lots of strange colours. Still, when asked if they know what color the brain is, the children attend to the colours of the drawing. The teacher points out that the image may not be adequate in this regard, This picture is fooling us, actually, because the brain is not really green or blue. While Malin and August have taken the colour of the drawing literally, as showing the colour of the brain, the third child, Richard instead suggests red. Asked to clarify why he believes the brain to be red, Richard in a somewhat shorthand way says, It [that which] is inside the body [is red]. Probably on the basis of experience of blood being red, Richard proposes that what (all that) is inside the body is red. In this way he disconnects the relationship between the representation (the drawing) and what it refers to and instead builds upon his experiences from elsewhere. The teacher confirms his observation in these terms, that is, in terms of blood being red. In this excerpt, the relationship between the representation and what is being referred to is thematised in conversation between the teacher and the children as not being of a simple corresponding, depicting, nature. Learning what to take as representing something and what is simply a feature of the representation as such, is an important lesson in science education.
After August having told about him bumping his head on a door knob, the teacher redirects the children's attention to the book she holds:

Teacher: Yes, there it is [Shows the book] Yes, we can see everything here, that's a pity. It's like this, this is also there, inside here, inside your chest in there, there is something here [points to the heart]. Do you know what this is sitting in here?
Children: No.
Teacher: It's something that says this: "Donk-donk, donk-donk".
One child: The heart!
Teacher: It's the heart, yes. Does anyone want to paint the heart?
Several children: Yes!

Continuing to speak about what is inside the body, the teacher asks what is behind the ribs. When the children respond that they do not know, the teacher uses a metaphorical utterance, It's something that says this: "Donk-donk, donk-donk", that is something (the heart) 'says' what she illustrates through onomatopoeia (i.e., an expression mimicking the sound of something).

With this assistance, the children in unison exclaim, the heart! Since all the children want to draw the heart on the paper they begun last week, the teacher uses a rhyme to arrive at August as the one who gets to draw it this time:

Teacher: Eeny, meeny, miny, moe, etc. … Ok, August gets to paint the heart. Does anyone know what colour, or, what colour do you want to use? [asks August]. Blue?
August: No [puts back a blue chalk], the heart is a red colour.
Teacher: The heart is red. Wait a minute [stops August]. Where does the heart go on this man or woman, this person? Where does the heart go?
August: Here [points].
Teacher: The heart goes here, yes.

[August draws the heart in the right place]

Teacher: Are you going to fill it in as well?
August: Yes. Blood [fills in with red]. That's what the blood should look like.
Teacher: Is there blood in the heart? What does the blood do in the heart then?
August: It will be sucked down to the tube.
Teacher: To the tube, which tube? [holds out the book with the picture and August points].
August: See, there are tubes!
Teacher: Exactly, that's quite right. And what do the tubes do with the blood, then?
August: They suck out.
Teacher: They suck out the blood? It's actually, you can see it here [shows on her own wrist], you can see them, small tubes. The blood comes here, and this blood is going back, back. You also have them if you look. If you look here. [Points to the children's wrists.] Look here. Look, here you have small tubes. It's back. Do you have them as well, Richard, do you have any tubes on here?
Richard: Yes. [Lifts up his foot]. I have them on my foot, too.
Teacher: Do you have tubes on your foot too, where then?
Richard: There. [Holds out his foot and points to a toe]
August: I've been bitten by a mosquito.
Richard: Yeah, a bit of blood.
Teacher: A little blood [inaudible] and the heart, as you said, it sucks out the blood in the body. And when it does this, donk-donk [shows with her hand], it is actually pumping out the blood.

The teacher's initial question here implies the hybrid nature of drawings as common in preschool practices, that is between depicting something in an 'accurate' manner and/or drawing as one likes (e.g., what colours one finds beautiful), Does anyone know what colour, or, what colour do you want to use? August chooses red, since the heart is a red colour. The undecided issue from the first event regarding the sex of the depicted person comes into

play when the teacher asks August where the heart should be drawn, Where does the heart go on this man or woman, this person? August fills out the contours of the heart while speaking (to himself), That's what the blood should look like. Hence, he motivates his choice of colour in terms of accuracy. The teacher connects to August's claim and extends the discussion, Is there blood in the heart? What does the blood do in the heart then? Working on the human body is not simply about depicting the parts of the body, the teacher recurrently directs the children's attention to the nature and functioning of these body parts. Hence, her agenda as it becomes evident in her questions and responses, does not simply aim at the children learning a list of names, but instead get an understanding of the human body and how it works. August is responsive to the teacher's questions and suggests, It will be sucked down to the tube. The metaphor of tube was introduced when looking at veins in the first event (see above). In talking with the child, the teacher uses the drawing of the book to coordinate the metaphor and its referent. The children and teacher look for veins (as evidence of the tubes) on their bodies, and notice additional examples. Finally, the teacher summarises the discussion and once again uses the gestural metaphor (showing with her hand the pumping of the heart) and its accompanying onomatopoetic expression, donk-donk.

Moving on from the heart, the stomach comes up for discussion:

Teacher: Where is your stomach? If this is the heart [points to the drawing].
Richard: Here. [Points to himself]
Teacher: [Points to the drawing] There, yes. That's where the stomach is. And what is in the stomach?
Richard: A little big hole. And food.
Teacher: Shall we see? [takes out the book] This is the stomach [points in the book]. This is also in the wrong colours. We don't have any colours like this inside the body, actually. Purple and green and so on, but I think they have tried to highlight it. This, do you know what this is called? [Points to the intestines] What does this look like, almost? What does it look like, do you think?
Richard: [Inaudible] …like a toothbrush.
Teacher: Like toothbrushes?
Richard: …like toothpaste.
Teacher: Like toothpaste, yes.

[---]

Teacher: Shall I tell you what it is called?
August: Mm.
Teacher: These are actually called your intestines, these ones. And this is the stomach, and this is where the food goes.
August: In the st…
Teacher: In the stomach. It's like a little bag that the food travels down into here.

Once again the issue of the arbitrariness of the colours of the organs in the book is commented by the teacher. In an interesting turn of phrase, the teacher pointing at the intestines on the image asks, This, do you know what this is called? and, What does this look like, almost? What does it look like, do you think? Hence, leaving aside for the moment the issue of how this body part is conventionally labeled, she opens up for the children to use their experiences and knowledge in making sense of what they see, what they think it looks like (cf. Chap. 9). Richard responds by suggesting, at first, like a toothbrush. However, this simile, expressed in this way, does not make sense to the teacher, as evident in her response, Like toothbrushes? Following up on how his utterance was taken by the teacher, Richard now rephrases what he means, like toothpaste. Phrased in this way, the simile makes sense to the teacher, responding, Like toothpaste, yes. Finally, the teacher introduces the conventional term, intestines and says a few words about its relation to another body part, stomach and this is where the food goes. With a new term and an explanatory simile the teacher responds to August's In the st…, In the stomach. It's like a little bag that the food travels down into here.

Continuing talking about the intestines and the stomach, the teacher asks if the children remember what it was called:

Teacher: And after the stomach, when the food has been there, it carries on [points in the book]. Do you remember what this is called, then?
Malin: Muscles.
Teacher: Yes, they are muscles, yes these are a type of muscles, because they pump around, but they are called intestines.
Richard: Yes, it's [inaudible] that I have.
Teacher: Yes. [Points in the book] And this is actually the large intestine and this is the small intestine. The large intestine and the small intestine.
Richard: [Unclear] the same as…

[---]

August: D'you know what, he did a P.
Richard: Yes, the same as Patrick.
Teacher: Mm. Yes, a P, the stomach looks almost like a P there. There are the intestines. Do you want to fill them in too?

While clarifying that this term is not quite the expected or conventional one, the teacher still supports Malin's suggestion by motivating how yes these are a type of muscles, because they pump around, but they are called intestines. Drawing the intestines, August points out that this looks like the letter 'P'. The similes used by the children indicate their experiences. In this case, seeing in terms of a cultural symbol (the letter P), contingent on him growing up in a literate culture where children tend to pick up (notice, discern) this

communicative and representational system well before they receive formal schooling in reading and writing. Metabolism is now thematised in the talk:

Teacher:	What happens to the food after it has been in the intestines, do you know?
One of the children:	Purple.
Teacher:	When the food first goes through the stomach, and when what is left over goes through all the intestines and when it comes out there, what happens then, do you think? Where does it go then?
August:	Down to the legs.
Teacher:	The blood actually absorbs the food here, taking what it wants. But what about what the body doesn't want?

In explaining what happens to the food, an animistic form of reasoning is used, as quite common in these kinds of explanations (Thulin & Pramling, 2009). In this case, the blood is said to `actually absorbs the food here, taking what it wants. But what about what the body doesn't want?` The blood and the body are thus spoken about in terms of intentional agents that `want` something. This kind of speech recurs during the activity.

Having spoken about what happens to the food in the body, lungs and breathing are introduced and spoken about. Here something interesting concerning the issue of representation comes up in the talk:

Teacher:	But do you remember now what we said? Oh. When we breathe. There was something else here. The heart took care of the blood, August. But there was something else beside the heart, around here, can you see? [points to the lungs in the picture in the book] What are these? Do you know what these are called? When you breathe, where does the air go?
[Children and teacher whisper – inaudible]	
Teacher:	They are called lungs!
Richard:	Lopopopo.
Teacher:	What a lot of words there are in the body, aren't there? It's the lungs are around the heart there.

Richard responds to the introduction of the new term, `lungs`, with a nonsense word that sounds somewhat similar in Swedish (`lungor`, `lopopopo`). Being sensitive to the children maybe finding all the terms introduced somewhat overwhelming, the teacher says that `What a lot of words there are in the body, aren't there?` In this way, the difference between the representation (in this case verbal terms) and what is referred to (bodily organs) is collapsed into one and the same, the body containing words (cf. Pramling & Säljö, 2007, for an analysis of such collapsing in the popularization of scientific knowledge for lay audiences in popular science journals).

Next part to talk about and to draw on the large sheet of paper is muscles:

Teacher: Mm, you have really good muscles. Shall we see if they have a picture of muscles here? I don't know if they have one. Here we are, they do actually have a picture. Can you see, what they have coloured red here, these are meant to be the muscles, which sit outside of the yellow, which is meant to be the skeleton. Do you see? Can you see it too [shows the book to Malin and Richard]?
Richard: Is it here?
Teacher: Yes, look, do you see? It's the same there, yes.

Looking at the book, the teacher again makes the children pay attention to the arbitrariness of the colouring of the organs, Can you see, what they have coloured red here, these are meant to be the muscles, which sit outside of the yellow, which is meant to be the skeleton. She thematises this issue by making the distinction between what they (the authors, illustrators of the book) meant, to what is implied to be how it is. Hence, she hints at the important fact that the representation cannot be taken at face value, simply read off as being an 'adequate' illustration. Some interpretative work is required of the reader.

Having now finished the drawing of the human body, the issue of what, more specifically, this is a representation of, again comes up, as before, in terms of sex:

Teacher: Look here, shall we write what they are called? Shall we give this fine person a name?
August: Yes! Yes, he can be called August.
Richard: No, Richard!
August: No, August!
Teacher: Maybe we should find another name, that nobody in this group has?
Richard: Helen!
Teacher: That's my name. Can we come up with something that nobody here is called? Malin, do you have any suggestions?
Malin: Mmmm…
August: [Inaudible]
Teacher: Mr, what did you say?
August: Mr Mästerson.
Teacher: Mästerson?
Malin: Kurt.
Teacher: Kurt Mästerson? Shall we call him that?
Malin: [Nods]
Teacher: That's a wonderful name, I think. Is it a man, then?
Children: Yes.

Asked to name the person on the paper, August and Richard immediately each suggests their own name. Sensing that this will not be solved, the teacher instead suggests that they find a name that is not represented by any of the children in the group. August suggests Herr Mästerson, literally Mr. Masterson, to which

Malin adds a first name, Kurt. The teacher and children thus settle the matter with Kurt Mästerson [Kurt Masterson]. Thus, as the teacher asks the children, and they confirm, this is a drawing of a man.

Rounding off the activity, the teacher writes down on the paper, the name of the person depicted as well as the different body parts:

Teacher: OK! Do you know what I thought I would do first, before we finish? I thought I would write what this actually is, because we may perhaps need to know it and remember it. I'll write it with a fine little pen like this. So let's see. I'll start with this. What was this? Do you remember? [Points to the eyebrows]
Children: Eyes!
Teacher: It was eyes, yes. And what was above the eyes.
Malin: [Points to herself] Eyebrows.

This mode of representing, that is, writing the names of what they have drawn (cf. above) is introduced as a matter of being able to remember at a later time what they have drawn. Hence, per implication, the visual representation is not self-explanatory and something else may be required for the drawing to serve as an external memory (cf. Säljö, 2005) at a later point in time. As a consequence of this practice, the children also get to review and are helped to remember what they have done and spoken about during the event:

Teacher: August! Mm. What was this? [Points to the heart]
One child: The heart.
Teacher: It was the heart.
One child: It's an A.
Teacher: It looks almost like an A, yes. What was under the heart here, then? [points to the stomach]
One child: Uh, a P.
Teacher: It was where. It was the P, yes. And what was the P, do you remember? It was where the food goes first. Sto…
Malin: They're my, it's my…
Richard: Stomach.
Teacher: Stomach, yes.

When asked to name the objects depicted, the children again use their experiences of the representational system of the alphabet to make sense of what they see. Hence, the heart looks like, or in the child's own terms, is an A. Certainly, a conventionally drawn heart looks like the letter A turned upside down. The teacher also confirms this suggestion as making sense. Asked what is depicted below the heart, one of the children says that it is a P. As introduced by a child earlier when they spoke about the stomach and looked at the illustration in the book, this letter is used in speaking about what something looks like. While the children at first do not seem to remember what the letter represented, that is what it was, instead remembering the symbol in terms of which they perceived it, with some further support by the teacher, Sto…, Richard remembers, stomach.

The activity ends, after half an hour, with the following:

Teacher: Right! I think that Kurt Mästerson is ready, don't you. That's really nice. So we'll talk about the skeleton next time. The thing you talked about, OK [turned towards August].
August: Mm.

The illustration as `really nice (fin)`, that is (also) an object of aesthetic concern, implicating the hybrid nature of this representational practice that we saw earlier is also here touched upon. Finally, the topic of the next event in this theme is mentioned, `So we'll talk about the skeleton next time.` In this way the teacher contextualizes forward, thus supporting the children in being able to connect various events into a narrative, an education in Mercer's (1995, 2008) terms.

10.3.4 Observing and Speaking About a Skeleton

For the third and final activity of the theme, 'The (inside of the) human body', the teacher has a surprise for the children. She has borrowed a full-size skeleton-model of a human being from the local hospital. One of the children immediately says that it is a skeleton.

Malin: It's the skeleton.
Teacher: Yes, exactly. You remember, when you explained about everything that was, that was in the body.
Polly: But, but it's the skeleton. [Creeps forward and points to the skeleton]
Teacher: Yes, that's the skeleton, yes. That's what we have inside here, inside our skin [points to her arm] and our muscles and everything. It's called the skeleton

[---]

Teacher: Let's see, he can sit down here, or she can. Maybe this is Kurt's skeleton? [Teacher says something unclear]. Do you want to come forward?
All the children: Um.
Teacher: Come on! Do you want to feel? This – what do you think this is? [Cannot see what the teacher is pointing at]
Malin: It's the stomach?
Teacher: Yes, can you feel it in here? If you feel here, if you feel on yourselves, you will feel that it is a little bumpy there, right? It is these bones that you feel when you press here on your chest. Inside

	here, what is sitting inside here, do you know?
Eva:	Blood!
Teacher:	There is blood, yes, and something that beats dunk-dunk dunk-dunk.
Malin:	The heart!
Teacher:	The heart is inside there. Do you remember what we breathed with, then?
Polly:	But, but, but Helen, Helen?
Teacher:	Wait, you can ask questions soon. Do you remember what we breathed with? Llll..?
Polly:	Luckiness?
Teacher:	Ll… yes, nearly. Our lungs! That's what we breathe with. Our heart and lungs are inside here.
Eva:	and Kato [unclear] had a really big heart.
Teacher:	Yes, he does, yes.

The teacher's questions and suggestions that the children feel the skeleton and their own bodies relate the model (the physical representation) to its referent (e.g., the ribcage). She also asks a somewhat ambiguous question, `what is sitting inside here, do you know`, and follows up by relating back to the previous occasion and what they talked about (and represented) then, such as the heart and the lungs. Again onomatopoeia works as a scaffold in illustrating and remembering something, `something that beats dunk-dunk dunk-dunk`. This support facilitates one of the children to remember, `the heart!`

In line with her pedagogical work, the teacher is apparently not content with staying at naming the parts of the body. She directs the children's awareness towards functions:

Teacher:	But why do you think we have a skeleton, then?
Richard:	I want to touch the ball.
Teacher:	Do you know? Does anyone have any idea why we have a skeleton? Why do we have it inside our body? Nobody has any suggestions? [The children shake their heads] Shall I tell you something? It's like this, if we didn't have this skeleton – is the skeleton hard or soft?
Polly:	It's hard!
Teacher:	Feel here on the chest. So if we, look here. When he has this hard skeleton, he can stand up [The teacher lifts up the skeleton].
All the children:	Mmm.
Teacher:	Can't he? But if he was completely soft, would he be able to stand up then?
Malin:	No.
Teacher:	With the skeleton we can stand, you see. And we can walk.

The teacher and children talk and think about what difference the skeleton makes to the human body. Hence, the teacher supports the children through her questions, to think about a relevant issue. She is not simply content with naming objects (parts of the body), that is, 'product' issues (what something is) but also process issues (functioning).

The children get to explore the skeleton by touching it and investigating how it looks:

```
Polly:    The teeth look funny!
Teacher:  Yes, and here we have the teeth. And here I can open
          up to get to the brain. Let's see! But is there a
          brain inside there?
Eva:      No.
Teacher:  No, because the brain is not part of the skeleton,
          but that's where the brain sits, in there. It's
          inside your heads. The hard bit – if you knock on
          the head. Whoah! [Polly touches the skeleton's head,
          causing a piece to almost fall off] Now we have to
          take care so that it doesn't break, OK? So that the
          head doesn't fall off.
Polly:    I want to feel inside there.
Teacher:  Of course you can feel.
Polly:    Oooh! What's in there? In here [Feels inside the
          skull, where the brain should be] what's in here?
Teacher:  It's just to make sure it stays attached there. [A
          screw inside the skull can be seen in the picture]
          It has to be secured it with little screws and so
          on, can you see? Otherwise it wouldn't have stayed
          in place.
```

Here an interesting issue concerning representation arises. Polly feeling the inside of the skull, exclaims, `Oooh! What's in there? In here, what's in here?` The teacher explains to her that `It's just to make sure it stays attached there.` Hence, is what the child feels inside the skull a part of the skeleton or merely a part of the model, the representation? As the teacher explains it is the latter. However, this observation is of more general interest. Since any representation means something standing for (representing, illustrating) something else, what is a feature of the representation (e.g., a model) and what is (also) a feature of its referent is always an issue to handle in this kind of learning.

Continuing investigating the skeleton, an interesting simile is introduced and taken up in the talk between the children and teacher:

```
The children [unclearly]:  The arm.
Teacher:                   Yes, can feel inside here that you
                           have this hard bit? It looks just
                           like this. And when we…wait now,
                           we'll see if we can do this.
Polly:                     And here are my muscles.
Teacher:                   Yes, when you move there, yes, you
                           have muscles, and when we move
```

	here, the skeleton moves like this.
Richard:	[Takes the skeleton's hand] Good day, good day.
Teacher:	Good day, good day, you say, hello it says back. Do you have any questions about the skeleton here?
Richard:	Yes!
Polly:	These are the muscles. [Points to the ribs]
Teacher:	[To Polly] There are muscles that sit on the skeleton, yes. But what is this, then? [Points to the spine] If you look back here – come on! Come, Richard and Malin, come. If you look back here. What is this, the stomach goes there at the front.
Richard:	It feels like dinosaurs.
Teacher:	Yes, do you know what – I thought the same thing. Our back looks just like that of a dinosaur.
Richard:	And dinosaurs have this!
Teacher:	And feel, if I touch you here [on the back], can you feel that it is a little bumpy there? They're like small bumps, if you feel each other. And those bumps are these [shows on the skeleton].
Richard:	[Unclearly]
Polly:	It's like a person.
Teacher:	Yes, this is a person, yes.
Richard:	Yes, it feels like dinosaur, a dinosaur has these [points to the skeleton]
Teacher:	And you have them too.

Looking at the back of the skeleton and the spinal cord, Richard suggests that `It feels like dinosaurs.` This simile is readily understood by the teacher who confirms that `I thought the same thing. Our back looks just like that of a dinosaur`, and thus at the same time reformulates the simile from how it feels (tactility) to how it looks. Richard excitedly replies, `And dinosaurs have this!` It is commonly known that many children are fascinated by dinosaurs and having seen drawings and perhaps skeletal remains of dinosaurs constitute an important experience for how they make sense of and communicate about what they see, looking at the model of the human skeleton. The teacher returning to the tactile part of exploration, redirects the children's attention to their own and thus the human body, `can you feel that it is a little bumpy there? They're like small bumps, if you feel each other. And those bumps are these` (showing on the skeleton). A new simile is thus introduced in describing what they feel and see, `like small`

bumps. Richard maintains his focus on dinosaurs, yes, it feels like dinosaur, a dinosaur has these (showing on the skeleton). The teacher responds, and you have them too. Thus, the teacher works in relating the model to its referent, the human body. The analogy between dinosaurs and the human skeleton provides incentive for this discussion.

Once more the issue of what belongs to the model (the representation) and what belongs to its referent, respectively, comes up in the talk:

Teacher: They are to make sure that everything stays in place. This are the ribs as well, and these are the shoulder blades, and here [shows Malin] are the shoulder blades back here.
Polly: Look here though, what about those ones? Those ones there? [Points under the pelvis]
Teacher: Which ones? Yes, those are also screws so that everything sticks together, otherwise we would have loose bits everywhere. Then we wouldn't have been able to say hello to Kurt here.

10.3.5 Drawing a Skeleton: Negotiating What to Include in the Representation

The teacher now introduces another representational practice to the model of the skeleton and speaking about it. The children are now to draw a skeleton on a paper. The task is introduced in the following way:

Teacher: Look how many fingers Kurt has?
Malin: [Counts the fingers] One, two…
Polly: Why is he called Kurt?
Teacher: Because last week they named the person we are painting over there Kurt, and I thought that this skeleton could also be Kurt. And do you know what we are going to do now? Kurt can sit here, and you are going to…we are going to get some black paper and white pens, because what colour is the skeleton?
All the children: White!
Teacher: You are going to paint your skeleton the way you think it looks inside your body. Just as Kurt has a skeleton, you have a skeleton too.
Malin: Can't we do each other?
Teacher: You're going to paint the skeleton on a piece of paper, but you can paint the skeleton of somebody else if you want. Your Mum's skeleton perhaps?
Many children: Yes!

Teacher:	Or your Dad's or Erik's or the baby's skeleton, everyone's skeleton looks like this [points to the skeleton] We also look like Kurt's skeleton.
Child:	[Unclearly]
Teacher:	I think you should try it.
Richard:	Then we could have a yellow one or a blue one.
Teacher:	They are actually white, though, skeletons.

The teacher continues speaking about the relation between the skeleton-model and the children, that they themselves look like this inside their bodies. One of the children asks, can't we do each other? That is, what is the drawing supposed to be a representation of? For the children this is apparently an important issue, while for the teacher this is of no importance since everyone's skeleton looks like this. We also look like Kurt's skeleton. Considering the drawing task, Richard says, then we could have a yellow one or a blue one. However, the teacher's response, they are actually white, though, skeletons, implies that this time it is not arbitrary which colour to choose and a representation that is in some regards 'correct' is expected of the children (cf. above, the discussions concerning the colours of the illustrations in the book of the inside of the human body).

Teacher:	It's like this, today you are going to paint on black paper. Today, I'm choosing. And you are going to paint your white skeletons. That you have.
Eva:	But I don't want to paint a skeleton.
Teacher:	I think [Unclear, whispering] You can do as much as you feel you can do. You can come and sit here to paint.
Eva:	But I don't want to paint a skeleton.
Teacher:	But we are trying, just like you can Eva. I think you can all paint beautifully.
Richard:	I can!
Teacher:	Your skeletons.

Hence, for this drawing task, the children each gets black paper and the white colour. The representational media introduced by the teacher in this case has important affordances and constraints that are well-designed for the present representational purpose. As we have already mentioned, drawing in preschool often takes a hybrid form between 'accurately' depicting something on the one hand and being allowed to draw whatever one wants on the other (see Bendroth Karlsson, 2011, for one such analysis). However, in the present case, as seen in the conversation between one of the children and the teacher, a representation of a skeleton is expected in a certain colour. Still, aesthetics is used as a strategy in encouraging the children to make the drawing. In response to Eva saying, but I don't want to paint a skeleton, the teacher responds, I think you can all paint beautifully.

The teacher moves the skeleton to the table where the children have taken their seats, so that they can look at it while making their drawings.

```
Polly:    Can I paint the hair?
Teacher:  You can maybe all paint these [points to the ribs].
          He has these ones, you see. And then the chest,
          here. Under the head.
Eva:      But I can do a man, me.
Teacher:  Feel free, paint a man here.
Malin:    I'm painting my Mum!
Teacher:  Are you painting your Mum's skeleton?
Malin:    Mmm.

[---]

Teacher:  Look, Richard has done that too. Look, it looks just
          like that too [points to the skeleton].
Richard:  That's me! That's me!
Teacher:  Is it your skeleton?
Richard:  Yes.
Teacher:  It looks just like that.
```

Being receptive to the teacher's introduction and follow up of the task, Polly asks, `can I paint the hair?` In most drawing tasks this kind of question would not come up, but this drawing activity has been framed in certain representational terms. The teacher's subsequent utterance redirects the children's attention to a part of the skeleton, `you can maybe all paint these` (pointing at the ribs). Clearly the children have understood that not only dinosaurs (see above) but also humans have skeletons, they themselves, their mothers, `a man`.

```
Teacher:  And you can see all these here under the head, then?
          [Points to the ribs] Can you paint them?
Malin:    What are they?
Teacher:  The ribs are these thing here we have in our chest.
          You can feel them here [shows on Malin].
Eva:      You can touch them, do you see [shows on herself].
Teacher:  Yes, you can feel them here.
Polly:    I've painted Kurt's mum [unclear].
Teacher:  Kurt's skeleton there, yes.
Richard:  Look, I've painted there.
Teacher:  Those are the ribs, I can see. Look, wonderful. And
          then you have this long sausage [points and shows
          the spine] which goes in the middle, down to the
          pelvis where the bottom was at the back, wasn't it?
Richard:  Right!
Teacher:  Yes, very good Richard. And then there's this.
Polly:    I've already painted the bottom and the privates!
Teacher:  That's where the privates are, yes.
Polly:    I've painted the privates.
Teacher:  Very good. And then you have the legs here. First
          one long one and then two. And then all the small
          toes. What a lot of bones we have here, don't we.
Polly:    Ready.
```

Malin asks what something she sees on the model is. The teacher names them ribs and shows on the child's own body where they are situated. Eva listens in and says that you can touch them, do you see, showing on her own body. The teacher also makes the children attend to another part of the skeleton through pointing at the model and using a metaphor to describe what they look at, And then you have this long sausage which goes in the middle, down to the pelvis where the bottom was at the back, wasn't it? Polly exclaims that I've already painted the bottom and the privates! [Swedish: snippan!] As will Eva later do and say, the girls appear to find it important to represent the sex of the person (the skeleton) they draw (cf. above, when drawing the outlines of a body and whether this is a man or a woman, a boy or a girl). While accepting and supporting the child in this, the teacher continues talking about the bones of the body.

Teacher: Yes, look, how wonderful. And you have done it just right, yes Malin. Look. How clever you all are. Eva too, really good, look.
Richard: [Unclearly] Look at me!
Teacher: Yes, I can see it, exactly. Shall we hold it next to it? Here we can see the eyes, and that's the mouth with all the teeth, and then you have all of these here and then here the long backbone sausage, you could call it.
Eva: And you have to have muscles.
Teacher: Mm, there are no muscles on the skeleton, do you see. We don't actually have them, we can paint them another day.
Polly: Look!
Teacher: There it is, yes, and there are the arms too. And are these the fingers here, do you think?
Polly: They're the fingers.
Teacher: They are the fingers, yes, excellent.

While being introduced and framed as a representational task, the children's drawings are still valued in aesthetical terms. The metaphor of the long backbone sausage returns, now merged with its reference, the spine. One of the girls wants to draw the muscles, but the teacher makes her attend to these not being a part of the skeleton and that they therefore can be drawn another time. Polly's utterance, look! is of some interest to our pedagogical concerns. As clarified by developmental researcher, Michael Tomasello (1999), human beings have a unique proclivity to make others attend to what they themselves attend. Two (or more people) sharing attention on something third (in this case a part of the human skeleton) could be considered the very foundation of what we refer to as an education and to pedagogy (cf. Pramling & Pramling Samuelsson, 2010).

The activity and the theme end by the teacher congratulating the children on their really beautiful skeletons you have drawn now, and that they should hang their drawings on the wall.

10.4 Discussion: Learning to Represent

Illustrating and analysing these three consecutive learning events on the theme of the human body, with a particular interest in issues of representation, a number of important features have come to the fore. In this final section of the chapter we will summarise these and discuss their importance and implications for children's science learning. Throughout the three episodes we can observe the following features important to children's science learning and representational knowledge:

Children as well as the teacher use metaphors and similes to describe the appearance of what they see, or what the children by the teacher are encouraged to see (`brown peas, like tiny grain of sand, backbone sausage`). This observation is important for several reasons. One thing this use of language implies is the important difference between discerning something and making sense of what is discerned. Learning about nature is not only about noticing certain aspects and phenomena as significant, but also about perspectivising these in relevant and interesting ways. The frequent introduction in this activity (and similar activities as analysed in other chapters of this book) of metaphorical speech and similes also testify to the importance of a teacher and child not only sharing attention (observing the same thing) but also coordinate perspectives on what is observed. The utterances describing what is perceived in terms of similes and metaphors work in establishing a shared perspective. A kind of mutual ground is thus established in the talk between children and teachers. Without any such ground, teachers and children could perceive the phenomenon in entirely different and unrelated ways, making it difficult to contribute to the child's further understanding. The use of metaphors and similes further illustrate the dialectics between everyday concepts and scientific concepts as emphasized by Vygotsky (1987) as necessary for the development of the latter kind of insight.

Another feature of the activity shown by the analysis in this chapter is the importance of learning and distinguishing between representing what one knows is there versus only representing what can be seen from a certain perspective (e.g., `the bottom` in a drawing of a body viewed from the front side). That children often draw what they know is there regardless of whether they can actually observe that feature from where they stand and observe, is well known in developmental literature (e.g., Piaget & Inhelder, 1969; see also Ivarsson & Säljö, 2005, for a discussion and illustration). To draw only what they see, as distinct from what they know is there, is difficult for the children, since it means that they have to disregard what they know. This is no easy task. Still, in terms of developing scientific skills, learning to observe in a closely scrutinized way how phenomena appear under various conditions is an important skill to develop. In science we have theory to not only make sense of what we observe but also to make sense of also what cannot be observed in any straightforward manner (Hanson, 1958/1981). Furthermore, learning to perspectivise phenomena in different ways, and knowing when one or the other perspective is relevant, are important to developing insights into the facts that phenomena can be constituted in language in many different ways and that different

traditions of knowledge such as biology, physics, poetry and so forth are premised on certain perspectives. There is no perspective-neutral way of making sense of the world and its phenomena; knowledge is conditioned certain perspectives.

In the analysis of the evolving activities concerning the human body, it was seen how aesthetic preferences reappeared concerning what to represent. This relates to the question of what kind of representational practice this is. Is the purpose to make an accurate representation, accurate for a certain purpose as seen from a certain perspective, or as a kind of art activity? As reported elsewhere, in early childhood settings, drawing is often given the form of a kind of hybrid activity, including both these aims, that is, to represent something 'accurately' and to express oneself 'freely' (see Bendroth Karlsson, 2011; Kress, 1997; Pramling & Pramling Samuelsson, 2011)? What kind of activity the making of drawings is, is seen in the teacher's introduction and responses to the children's suggestions and drawings during the activity. Making the drawings of the human body appear to be a multi-purpose activity. This is also a way of coordinating the children's sense making and interests and the intention of the teacher in making children aware of and understanding certain things.

Closely related to the issue of what kind of activity the drawing session that comes to the fore in these activities is what more specifically a representation should be a representation *of* (e.g., a human being, a man, a woman, a certain person such as the child him- or herself making the drawing, his or her mother, father, etc.). While for the teacher it does not matter which human being is illustrated, since the point is to learn about 'the human body', to the children this clearly makes a difference. The children relate the task to persons that are familiar and important to them, for instance a family member. To some extent, the issue of which human body is depicted is relevant to the task and it comes up for negotiation in terms of whether the body is a female or a male body. Some children also stay at this difference and integrate it into their drawing of the skeleton, resulting in a drawing that is a kind of hybrid.

Looking at the teacher in the followed activities, we can see how she makes many important things. For example, when a child introduces a certain metaphor, she confirms that what they talk about looks like this (i.e., simultaneously implying that it is not, in fact this) and says what it is. In supporting and clarifying the child perhaps thinking that it looks like this, the teacher motivates the child's suggestion as a relevant contribution but also adds something to further his or her knowledge. Metaphors and similes are representations in speech. An important distinction to clarify is therefore what something is and what is looks like, that is, how the utterance relates to its referent. Important as it is to learn to make such a distinction, when learning about phenomena, using the former, that is, what something looks like, to make sense of the latter, that is, what it is, shows the dialectics between everyday and scientific concepts (Vygotsky, 1987), as we elaborated on in Chap. 9. Learning that what something looks like is distinct from what it is, is important, but the former can be used as a resource in learning the latter, if it is thematised in conversation with for example a teacher. As seen when the second event commences, the teacher departs from a child's recollection of the previous occasion and expands

it further, as in this case typically going from what something is called to what function it fills for us, our human body. The teacher also makes important connections between representations (in the book and on their own drawings) to their own bodies, clarifying how the representations relate to their referents (e.g., veins). This is an important recontextualisation, weaving together the novel with children's experiences and also how different representations can be representations of the same thing, but in different ways.

The teacher also thematises what is a part of the representation as such (e.g., the brain being depicted by a blue colour in the book) as distinct from the nature of its referent. However, this colouring, which may be reasonable for illustrative purposes (making it easier to discern different organs) and aesthetic purposes, does seem to pose some difficulties to some children. As seen in the excerpt, one of the children responds to the teacher's question about what colour she thinks the brain is by saying blue, while other children give other suggestions (green, red). However, something to bear in mind is that the teacher's initial question is not unambiguous, and could in fact be taken as asking about the brain depicted in the book (which is actually blue). Hence, it is not clear that the children mistake the representation from its referent. Still, there is a potential problem even for older children in science education learning how to take representations such as models and other graphical depictions. For example, as reported by Molander, Pedersen and Norell (2001, p. 206), in their study from compulsory school, a student may reason about an atom in the following way: "there is something in physics, something to do with atoms […]. Something red and white and black.. some sort of ball". In addition to seeing how the student makes sense of the concept in more familiar terms (colours, ball), this reasoning points at the problem in learning to distinguish between a representation (how the phenomenon is mediated) and what it represents. The learner is faced with the issue of what features of the representation to consider relevant, for example, at different levels of description (e.g., atomic level and the level of the representation, respectively) (Pramling, 2006a). Another example of this issue is when a child asks what something is inside the skeleton and the teacher clarifies that it is only screws to make sure it holds together, and therefore not a part of the skeleton as such.

The teacher also, through her responses to the children's metaphors and similes, challenges the children to clarify what sense they make. For example, on one occasion a child suggests that the intestines looks like a `tooth brush`, which does not make sense to the teacher, as evident in her response. When not being able to establish temporarily sufficient intersubjectivity (Rommetveit, 1974; see also Chapter 11) with the teacher, allowing them to go on with the activity, the child responds by reformulating that the intestines look like `tooth paste`, which does make sense to the teacher. Through adjusting one's communication in this manner to an interlocutor, the child is socialized into attending to what he or she needs to make explicit to make sense to someone else and what can be left implied. This, of course, also implies that others may not understand and see the world as I do (see also in Chapter 11, where we discuss this matter).

Another interesting observation from the studied activities that cuts to the heart of the theme of the present book, is how children's perception is evidently semioti-

cally mediated (Wertsch, 2007) by their cultural knowledge. An example of this is when the children report seeing intestines as looking like certain letters of the alphabet (P, A). Growing up in a literate culture with this system also shapes the children's perception (Olson, 1994). In his fascinating study, and one of the classics of cultural-historical research, Alexander Luria (1976) report findings that illustrate how learners' perception (as well as other important cognitive and communicative functions such as categorizing and reasoning) change when they become participants in novel activities, in this case, in novel institutional arrangements. He studied what happened to adults who were allowed to attend school that had recently opened in an area previously without such an institution. Without going into the details of his extensive and rich study, for the present discussion, his work is important among other things for showing how even how we perceive the world and its phenomena changes, that is, is learned and that how we learn to perceive depends on what practices and cultural tools we are introduced to and come to appropriate (cf. Kozulin, 1998; Wertsch, 1998). These cultural tools will come to semiotically mediate (Wertsch, 2007) phenomena for the learner. Learning to see in institutionally relevant and expected ways means to perceive in terms of particular tools (Goodwin, 1994). As we have already pointed out above, when discussing the difference between a child drawing what he or she knows and what he or she can actually see from a certain perspective, the basis of scientific observation, that is, seeing should not be taken for granted as unproblematic to science education. Seeing in this context entails more than meets the eye.

The teacher is further important in recontextualising (van Oers, 1998) backwards and forwards (in addition to how they do so between representations and children's experiences, as we have already mentioned) between events. Through this 'weaving' (cf. the etymology of 'text' as writing and weave, Barnhart, 2000) what would otherwise risk becoming separate events or phenomena for the children are turned into what Mercer (1995, 2008) refers to as an education. An education, according to this notion, is more than simply a number of things learned (fragmentary facts). Rather, it presumes and consists of some kind of connected construal, a narrative of some sort that makes these meaningful in relation to, and in light of, one another. Such a relation is necessary to create continuity and thus cumulativeness in learning beyond simply learning different things. Notably, the children also recontextualise what they look at and speak about. In this case, they made sense in terms of referring to fictional stories (such as stories by Astrid Lindgren).

References

Änggård, E. (2005). *Bildskapande: En del av förskolebarns kamratkulturer* [Making pictures: A part of preschool children's peer cultures] (Linköping studies in arts and science, 315). Linköping, Sweden: Linköping University.

Aronsson, K., & Hundeide, K. (2002). Relational rationality and children's interview responses. *Human Development, 45*, 174–186.

Barnhart, R. K. (Ed.). (2000). *Chambers dictionary of etymology*. Edinburgh, Scotland: Chambers Harrap.

Bendroth Karlsson, M. (1996). *Bildprojekt i förskola och skola: Estetisk verksamhet och pedagogiska dilemman* [Arts projects in preschool and school: Aesthetic activity and educational dilemmas] (Linköping studies in arts and science, 150). Linköping, Sweden: Linköping University.

Bendroth Karlsson, M. (2011). Pictures of spring: Aesthetic learning and pedagogical dilemmas in visual arts. In N. Pramling & I. Pramling Samuelsson (Eds.), *Educational encounters: Nordic studies in early childhood didactics* (pp. 85–104). Dordrecht, The Netherlands: Springer.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.

Cuthbert, A. J. (2000). Do children have a holistic view of their internal body maps? *School Science Review, 82*, 25–32.

Daniels, H. (2005). Vygotsky and educational psychology: Some preliminary remarks. *Educational & Child Psychology, 22*(1), 6–17.

Donaldson, M. (1978). *Children's minds*. Glasgow, Scotland: Collins.

Fleer, M. (2009). Supporting scientific conceptual consciousness or learning in a 'roundabout way' in play-based contexts. *International Journal of Science Education, 31*(8), 1069–1089.

Goatly, A. (1997). *The language of metaphors*. London: Routledge.

Goffman, E. (1974). *Frame analysis: An essay on the organization of experience*. New York: Harper & Row.

Goodwin, C. (1994). Professional vision. *American Anthropologist, 96*(3), 606–633.

Guichard, J. (1995). Designing tools to develop the conception of learners. *International Journal of Science Education, 17*(2), 243–253.

Hanson, N. R. (1981). *Patterns of discovery: An inquiry into the conceptual foundations of science*. New York: Cambridge University Press. (Original work published 1958)

Hayes, D., Symington, D., & Martin, M. (1994). Drawing during science activity in the primary school. *International Journal of Science Education, 16*(3), 265–277.

Hundeide, K. (1977). *Piaget i kritisk lys* [Piaget in a critical light]. Oslo, Norway: Cappelen.

Ivarsson, J., & Säljö, R. (2005). Seeing through the screen: Human reasoning and the development of representational technologies. In P. Gärdenfors & P. Johansson (Eds.), *Cognition, education and communication technology* (pp. 203–222). Hillsdale, NJ: Lawrence Erlbaum.

Kozulin, A. (1998). *Psychological tools: A sociocultural approach to education*. Cambridge, MA: Harvard University Press.

Kress, G. (1997). *Before writing: Rethinking the paths to literacy*. London: Routledge.

Kress, G. (2003). *Literacy in the new media age*. London: Routledge.

Luria, A. R. (1976). *Cognitive development: Its cultural and social foundations* (M. Lopez-Morillas & L. Solotaroff, Trans.). Cambridge, MA: Harvard University Press.

Mercer, N. (1995). *The guided construction of knowledge: Talk amongst teachers and learners*. Clevedon, UK: Multilingual Matters.

Mercer, N. (2008). The seeds of time: Why classroom dialogue needs a temporal analysis. *Journal of the Learning Sciences, 17*(1), 33–59.

Molander, B.-O., Pedersen, S., & Norell, K. (2001). Deaf pupils' reasoning about scientific phenomena: School science as a framework for understanding or as fragments of factual knowledge. *Journal of Deaf Studies and Deaf Education, 6*(3), 200–211.

Olson, D. R. (1994). *The world on paper: The conceptual and cognitive implications of writing and reading*. Cambridge, UK: Cambridge University Press.

Osbourne, J., Wadsworth, P., & Black, P. (1992). *Processes of life: Primary SPACE project research report*. Liverpool, UK: Liverpool University Press.

Óskarsdóttir, G. (2006). *The development of children's ideas about the body: How these ideas change in a teaching environment* (Diss.). Reykjavík, Iceland: University of Iceland, Faculty of Social Sciences.

Piaget, J., & Inhelder, B. (1969). *The psychology of the child*. London: Routledge & Kegan Paul.

Pramling, N. (2006a). *Minding metaphors: Using figurative language in learning to represent* (Göteborg studies in educational sciences, 238). Göteborg, Sweden: Acta Universitatis Gothoburgensis.

Pramling, N. (2006b). 'The clouds are alive because they fly in the air as if they were birds': A re-analysis of what children say and mean in clinical interviews in the work of Jean Piaget. *European Journal of Psychology of Education, 21*(4), 453–466.

Pramling, N., & Pramling Samuelsson, I. (2010). Evolving activities and semiotic mediation in teacher-child interaction around simple objects. *Educational & Child Psychology, 27*(4), 22–30.

Pramling, N., & Pramling Samuelsson, I. (2011). En korpus av kunskap – förhandling mellan lärare och barn om att representera den mänskliga kroppen i en bok. In V. Glaser, K. H. Moen, S. Mørreaunet, & F. Søbstad (Eds.), *Barnehagens grunnsteiner. Formålet med barnehagen* (pp. 176–187). Oslo: Universitetsforlaget.

Pramling, N., & Säljö, R. (2007). Scientific knowledge, popularization, and the use of metaphors: Modern genetics in popular science magazines. *Scandinavian Journal of Educational Research, 51*(3), 275–295.

Reiss, M. J., Tunnicliffe, S. D., Andersen, A. M., Bartoszeck, A., Carvalho, G. S., Chen, S. Y., et al. (2002). An international study of young peoples' drawings of what is inside themselves. *Journal of Biological Education, 36*(2), 58–64.

Rommetveit, R. (1974). *On message structure: A framework for the study of language and communication*. London: Wiley.

Säljö, R. (2005). *Lärande och kulturella redskap. Om lärprocesser och det kollektiva minnet* [Learning and cultural tools: On processes of learning and collective memory]. Stockholm: Norstedts.

Säljö, R., & Wyndhamn, J. (1993). Solving everyday problems in the formal setting: An empirical study of the school as a context for thought. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 327–342). New York: Cambridge University Press.

Thulin, S., & Pramling, N. (2009). Anthropomorphically speaking: On communication between teachers and children in early childhood biology education. *International Journal of Early Years Education, 17*(2), 137–150.

Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.

Tunnicliffe, S. D., & Reiss, M. J. (1999). Students' understandings about animal skeletons. *International Journal of Science Education, 21*(11), 1187–1200.

van Oers, B. (1998). From context to contextualizing. *Learning and Instruction, 8*(6), 473–488.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987). *The collected works of L. S. Vygotsky, Volume 1: Problems of general psychology, including the volume* Thinking and Speech (R. W. Rieber & A. S. Carton, Eds., N. Minick, Trans.). New York: Plenum.

Vygotsky, L. S. (1991). *The psychology of art*. Cambridge, MA: MIT Press.

Vygotsky, L. S. (1997). *The collected works of L. S. Vygotsky, Volume 4: The history of the development of higher mental functions* (R. W. Rieber, Ed., M. J. Hall, Trans.). New York: Plenum Press.

Vygotsky, L. S. (1998). *The collected works of L. S. Vygotsky, Volume 5: Child psychology* (R. W. Rieber, Ed., M. J. Hall, Trans.). New York: Plenum.

Wells, G. (2007). Semiotic mediation, dialogue and the construction of knowledge. *Human Development, 50*(5), 244–274.

Wertsch, J. V. (1998). *Mind as action*. New York: Oxford University Press.

Wertsch, J. V. (2007). Mediation. In H. Daniels, M. Cole, & J. V. Wertsch (Eds.), *The Cambridge companion to Vygotsky* (pp. 178–192). New York: Cambridge University Press.