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Ways of dealing with science learning: a study based on Swedish early childhood education practice

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ABSTRACT

The Swedish school system offers curriculum-based early childhood education (ECE) organised as preschool (for 0–5-year-olds) and preschool class (for 6-year-olds). The intention to create a playful and educational environment based on children's perspectives, interests, and questions is strongly based on historical and cultural traditions. This article develops knowledge of ECE teachers' approaches to science-learning situations. The study applies a phenomenographic approach. The analysis is based on approximately 9.5 hours of video documentation of teacher-led and child-initiated Swedish ECE science activities. We identified two descriptive categories and four subcategories dealing with science-learning situations: (A) *making anything visible*, containing the three subcategories (Aa) addressing everyone, (Ab) addressing everything, and (Ac) addressing play and fantasy; and (B) *creating a shared space for learning* (Ba) addressing common content. These categories are related to how efforts to take advantage of children's perspectives are interpreted and addressed in educational practice. The article discusses and exemplifies the use of various categories and their potential implications for ECE learning practice.

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Children's perspectives; early childhood education; phenomenography; science learning; teachers' approaches

Introduction

According to Siraj-Blatchford and MacLead-Brudenell (1999), science in early childhood education (ECE) entails taking advantage of and building on children's everyday experiences. This way of relating to learning (in general) and to science learning (in particular) is deeply rooted in Swedish ECE tradition (Thulin, 2011) and in the national curriculum (Ministry of Education and Science, 1998/2010), which states that educational practice should be based on children's experiences, interests, motivations, and drive to seek knowledge. ECE teachers continuously facilitate groups of children who have various questions, interests, and degrees of curiosity, and it is indeed a challenge to handle and coordinate such diverse elements simultaneously. The present study concerns the ways ECE teachers address science-learning situations in daily practice by seeking to identify qualitative categories using a phenomenographic approach (Marton & Booth, 1997). These categories are related to how efforts to take advantage of children's perspectives are interpreted and addressed in Swedish ECE science practice.

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Background

The Swedish school system offers curriculum-based ECE organised as preschool (for 0–5-year-olds) and preschool class (for 6-year-olds). This educational practice is internationally known to be high quality, playful, and based on children's perspectives, interests, and questions. This ECE practice is based on a cultural tradition grounded in the work of Fröbel (1782–1852), who advised teachers to follow children's interests and development, and to take advantage of them in teaching situations (Fröbel, 1826/1995). Both the individual child and the group are supposed to be at the centre of pedagogical planning and ECE practice. Since the late 1990s, Swedish educational practice has been strongly influenced by what is called 'developmental pedagogy', developed by Pramling Samuelsson and Asplund Carlsson (2008). In developmental pedagogy, children's learning and development start with children's perspectives, endeavouring to capture children's interest by exploiting both structured and everyday situations (Pramling Samuelsson & Asplund Carlsson, 2008).

The Swedish ECE mission is clearly stated as about caring, fostering, and children's learning. However, the curriculum revisions implemented in 2011 (Ministry of Education and Science, 1998/2010) strengthened the emphasis on children's learning, in response to evaluations indicating that there may be an imbalance between the three elements, with children's learning losing out (The Swedish Schools Inspectorate, 2012). ECE teachers are sometimes criticised for not systematically stimulating children's learning (Sheridan, Pramling Samuelsson, & Johansson, 2009) and ECE practice is sometimes even described in terms of a 'doing culture' emphasising what to do instead of what to learn (Pramling Samuelsson & Asplund Carlsson, 2008), similar patterns being found internationally (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2010).

The revised curriculum specified several content areas, such as mathematics, reading, writing, and science, and gave goals a prominent place (Ministry of Education and Science, 1998/2010). With this change, current Swedish ECE practice is facing new challenges related to its established tradition and new emphasis in relation to children's learning. It can be described as a way to both preserve and develop the specific character of ECE (Jonsson, 2013). One way to address such challenges is to do what one has always done, that is, include the new within the established discourse by incorporating change in prevailing cultural traditions (Thulin, 2006), taking an educational approach that could obscure the new (Thulin & Pramling, 2009). Another way to understand this is to pay attention to research demonstrating that it can be difficult for ECE teachers to fulfil their new mission. These difficulties are attributable to, first, a lack of theoretical tools (e.g. derived from new research into learning in early years) to support the new requirements and, second, a lack of knowledge related to various content areas (Thulin, 2011).

Given this background, we need discussion of what ECE teachers' changed commission entails. Trying to combine a strengthened educational mission with an ECE tradition strongly based on children's perspectives and interests highlights certain matters (see, e.g. Pramling Samuelsson & Asplund Carlsson, 2008), for example, the potential pedagogical implications for teachers' ECE activities, content handling, and didactic approaches (Ljung-Djärf, Mårdsjö Olsson, & Thulin, 2013; Thulin, 2011).

Previous research

This study is concerned with two bodies of research: on teachers' didactic approaches and on ECE science learning.

Teachers' didactic approaches

The starting point of this study is the view that children are born with a willingness to understand the world around them (Bruner, 1960/1996) and that prerequisites for children's learning are largely created in their environment and in the relationships they have with adults/teachers and peers. However, it is the children themselves who create their meanings and their understandings of the surrounding world (Karlsson Lohmander, 2004). Several researchers, including specialists in science education, emphasise the importance of communication in children's learning (see, e.g. Elstgest, 1999; Helldén, 1992). Developmental pedagogy research has demonstrated that an important point of departure for children's learning is making the object of learning (i.e. what is to be learnt) visible and inducing children to think about and reflect on this. One way to accomplish this is to use metareflective dialogues (Pramling Samuelsson & Asplund Carlsson, 2008) through which children can become aware of otherwise hidden or unquestioned phenomena and connections. Metareflective dialogues can draw attention to what is happening and to how children experience what is happening. In the framework of developmental pedagogy, three levels can be the object of learning: level 1 entails directing attention to the chosen content, and then exposing the children's experience of the content to reflection. Communication at level 2 entails making general structures visible. Level 3 is the metareflective level and the most general of the three levels. Here, the children's attention is directed towards what, how, and why something is, happens, or is done in a particular way. Discussions of different ways of learning occur at this level.

ECE teachers and the learning activities in preschools have often been criticised for overemphasising a doing perspective in learning situations, at the risk of hiding the learning object from children (Pramling Samuelsson & Asplund Carlsson, 2008). Research demonstrates the importance of directing attention both to children's experiences and to the learning object itself (Pramling, 1994). In that way, both the object of learning and the act of learning are made inseparable parts of the learning process. The learning object can be described as the intentional object of learning, the lived object of learning, and the enacted object of learning. The enacted object of learning is constituted in communication between the teacher and the learners and between the learners themselves, creating a shared space for learning (Marton, Runesson, & Tsui, 2004). Pramling (1994) demonstrated that children involved in learning activities associated with this didactic approach displayed higher awareness of the chosen content than did children in comparison groups.

Results of several studies concerning children's learning note the mutuality of communication between teacher and child as an important aspect. For example, the study *Effective Provision of Pre-school Education* (EPPE) in the UK demonstrates that in high-quality preschools there is mutuality in teacher–child communication (Sylva et al., 2010). The same finding has been noted by some Swedish studies as well (Sheridan, 2001; Sheridan et al., 2009). The teachers involved in these studies strove to meet the

children on their own ground and to create connections between the children's experiences and the learning object. Such communication can be considered 'shared sustainable thinking' (Siraj-Blatchford, Sylva, Muttock, Gilden, & Bell, 2002). This concept is used to highlight two aspects of teacher–child communication: mutuality and common content.

Research from the USA has arrived at similar results. Yoshikawa et al. (2013) studied the effects of preschool programmes and identified two interrelated dimensions of teacher–child interaction as qualitatively important for children's learning and development: the first dimension is described as 'interactions explicitly aimed at supporting learning, that foster both higher-order thinking skills in general and learning of content in such specific areas as early math and language', and the second dimension as 'learning across multiple domains … enhanced in the context of warm, responsive teacher–child relationships and interactions characterized by back and forth – serve and return – conversations to discuss and elaborate on a given topic' (p. 6). Teacher interaction is here related to children's learning at both the general and specific levels. The importance of communicating in a warm, trustful, and mutual way is stressed.

ECE science learning

ECE science, in the sense of children being indoors or outdoors, playing in, examining, and discovering nature, has a long and strong tradition in Sweden and other countries. In a certain sense, young children are 'doing science' most of the time, by experiencing and developing theories about the surrounding world. Eshach (2011) emphasises that ECE science is not only observing and learning to enjoy nature, but also being involved in collective, structured science inquiry. The teacher's ability to create conducive science-learning environments is dependent on preparation in how to design and provide children with efficient science-learning frames (Eshach, 2011). Key factors in such scaffolding include the teacher's knowledge of the subject (Siraj-Blatchford et al., 2002; Thulin, 2011), an appropriate scientific language that makes it possible to talk about the science content in a scientific way (Cunningham, Zibulsky, & Callaghan, 2009), scientific attitudes as well as assumptions related to science and young children (Fleer, 2009), and relation competence (Nordenbo, Søgaard Larsen, Tiftikçi, Wendt, & Østergaard, 2008).

Beyond that, Eshach (2006) has found that research into ECE science learning has identified two relevant fields of knowledge: conceptual knowledge and procedural knowledge. Conceptual knowledge concerns children's learning and featured content, that is, concepts or ways of describing relationships. Procedural knowledge concerns scientific methods, that is, the ability to conduct investigations, ask questions, analyse data, search for patterns, and so on.

Available research demonstrates that ECE science activities occur in several forms and contexts for various purposes that are not always planned in advance, but rather respond to children's spontaneous curiosity regarding observed phenomena. This raises important questions, including how to use children's interests stimulated by observing natural phenomena. Interesting research into this matter was conducted by Hansson, Löfgren, and Pendrill (2014), who examined the featured science content when 21 teachers followed up on children's questions about everyday situations. The study found a wide range of content in children's questions, implying a major challenge for the ECE teachers

trying to build science-learning situations based on these questions. The study highlights the opportunities and difficulties that ECE teachers may encounter when trying to use children's questions and everyday situations as a basis for science learning. Hansson et al. (2014) conclude that ECE teachers must be prepared to identify issues and situations that may have reasonable science content. They also suggest that teachers must learn to choose between such issues and situations, to create meaningful experiences for the children and possible starting points for further scientific learning.

Aim and research questions

The aim of the study is to develop knowledge of ECE teachers' approaches to science-learning situations. The research questions are:

- What content do the teachers concentrate on in science-learning situations?
- How do the teachers respond to children's expressions?

Implementation

Sample and participants

The data for the analytical case were collected from four previously reported research projects (Gustavsson & Pramling, 2014; Jonsson, 2013; Ljung-Djärf, Magnusson, & Peterson, 2014; Thulin, 2011). In the present study, we sought teacher-initiated activities addressing various kinds of science learning. When re-examining the empirical material from the above projects, we found about 9.5 hours of video-recorded material with relevant content; this was used as the sample of empirical material analysed here.

The empirical material was collected in four Swedish ECE settings located in areas with various socio-economic conditions and home to some children with Swedish as a second language. Although the study does not concentrate on the children per se but on the teachers' approaches, it is important to know that Swedish ECE is conducted in groups of children aged 1–6 years. The material accordingly covers participating children of a wide range of ages.

In total, the data cover 7 teachers and 65 children aged 1–6 years. The teachers were all female with preschool teacher education and long experience of ECE work. The material collected in each project is described in Table 1. The studied children had their parents' permission to participate on the days of study observation.

Table 1. Characteristics of the projects and participants.

	The frame	Teachers	Children	Video-documented material
Project 1	The project examined teachers' verbal communication with children	$n = 1$	$n = 5$; 1–3-year-olds, 3 girls and 2 boys	2 hours
Project 2	The project examined organic decomposition	$n = 5$	$n = 33$; 4–5-year-olds, 15 girls and 18 boys	1 hour
Project 3	The project examined what woodlice eat	$n = 3$	$n = 21$; 3–6-year-olds, 10 girls and 11 boys	4.5 hours
Project 4	The project examined the life of ants	$n = 1$	$n = 5$; 4–5-year-olds, 2 girls and 3 boys	2 hours

Ethics

The project was guided by the ethics standards set by the Swedish Research Council (2011). All participants (that is, parents, teachers, school management, and children) were continuously informed of their rights to confidentiality and to withdraw from participation. Informed consent was obtained from all adult participants, from parents on behalf of their children, and from the children themselves. Research involving young children, who cannot easily make their case or assess potential research impacts (Heikkilä & Sahlström, 2003), entails special requirements regarding research ethics; these were the subject of continuous consideration throughout the study.

The process of analysis

In this research, we (four researchers and well as experienced preschool teachers) aimed to improve the knowledge of science-learning situations and its potential implications for ECE learning practice. Our analysis is based on transcribed video-recorded observations from four projects in which: (1) all researchers first transcribed and analysed their own material; (2) the results were then discussed and reanalysed in the research group; (3) all selected situations were divided into potential categories; and (4) four situations were then chosen to represent the identified categories and subcategories. The study is influenced by the phenomenographic approach (Marton, 1981; Marton & Booth, 1997; Uljens, 1989), which entails identifying and tackling 'questions of relevance to learning and understanding in an educational setting' (Marton & Booth, 1997, p. 111). From an ontological standpoint, phenomenography stresses that there is only one world but that people's experiences of it differ. These experiences can be decisive for how, for example, an ECE teacher interprets teaching in ECE settings. Differences in how something is experienced mean that some aspects are emphasised at the expense of others.

> In order to make sense of how people handle problems, situations, the world, we have to understand the way in which they *experience* the … situations … that they are handling or in relation to which they are acting. (Marton & Booth, 1997, p. 111, emphasis in the original)

Marton and Booth (1997) state that two aspects of any learning situation are analytically important for the researcher: 'They are referred to as the "what" of learning and the "how" of learning' (p. 135). Marton and Booth (1997) point out that the overarching principle of achieving high-quality learning entails thematizing both the act and content of learning during the act of teaching. The descriptive categories that we have identified constitute the outcome space of qualitatively different ways in which ECE teachers, at a collective level, address the constitution of good educational practices. In the analysis, our research questions were emphasised as we sought the meaning and structure of teachers' approaches and responses to children's expressions. The results capture the relationship between the different identified categories; in the analysis, we have striven for as few descriptive categories as possible (Marton & Booth, 1997).

Results

The results are presented in two qualitatively different descriptive categories: (A) *making anything visible* and (B) *creating a shared space for learning.* Descriptive category A

contains three subcategories: (Aa) addressing everyone, (Aa) addressing everything, and (Ac) addressing play and fantasy. Descriptive category B contains one subcategory: (Ba) addressing common science content. Each subcategory is illustrated by quotations from dialogues between teachers and children. All informants' names are fictive.

(A) Making anything visible

This category is characterised by an approach in which active, communicative teachers encourage everyone to join in and pay attention to anything that comes to mind in the present situation. We interpret the intended learning object as vague or as constituting many things simultaneously. Three subcategories are described below.

(Aa) *Addressing everyone*. The sequence illustrating this category takes place outdoors in a sandpit (project 1, Table 1). According to the teacher's explanation, the sequence concerns the technique of making sand cakes. The children were aged 1–3 years and the teacher is sitting on the edge of the sandpit with two children, Jennifer and Ellie, one on each side, while Alfred, Erica, and Agnes are standing just outside the sandpit. These young children indicate their interest by showing something and/or saying one or two words.

Excerpt 1

Teacher:	Do you want to join us, Alfred? Do you want to join us and dig?
Alfred:	Yes.
Teacher:	Then you get this. [holds out a green shovel] There you are. Here is an octopus. [shows a red mould] Do you want to dig, make something like an octopus cake?
Teacher:	[fills Jennifer's bucket with sand] One, two, three! [On the count of 'three' the teacher turns the bucket upside down in front of Ellie. Two more children, Erika and Agnes, come forward, watching what they are doing.]
Erika:	Hey, hey!
Teacher:	Hey, hey. If you want to come and dig, you may as well pick up a shovel.
Erika:	No.
Teacher:	Yes, please. Don't you both want to join us?

The analysis concerns how the teacher responds to the children's expressions and what she emphasises in her responses. In this example, the teacher pays attention to each child by inviting them to join in the same activity and offering them toys for playing with the sand. She takes into account what they say, begs them to join in, and makes suggestions about what they should do. Using a shovel and bucket, the teacher is making sand cakes with Jennie and Ellie when she invites Alfred to join them and dig in the sand. She offers Alfred a shovel and a mould for making another sand cake in the shape of an octopus. At the same time, she fills the bucket and then turns it upside down after counting to three, in order to make a new sand cake with the bucket. When a fourth child, Erica, says 'Hey, hey!', the teacher answers, inviting and even begging Erica and Agnes to join them and dig. Erica and Agnes stay but do not take part in making sand cakes.

Considering the phenomenon 'addressing everyone', this excerpt illustrates how each child is included when they are invited to participate in the group activity. Rather than an intended learning object, the focus here is on children doing things together, which can make it difficult for the children to discern the teacher's explicit scientific aim in the activity, namely, to learn a technique for making sand cakes.

(Ab) *Addressing everything*. This category is illustrated by a teacher-initiated situation addressing organic decomposition (project 2, Table 1). Nine 4- to 5-year-olds and two

teachers are gathered around a large box containing partially rotten and mouldy sticks and vegetables and some woodlice. The children are allowed to explore the items in the box quite freely in order to learn about decomposition. The teachers act as dedicated co-explorers, who suggest words, trying to expand and discuss the findings. The focus on decomposition, though, is in the background, while the rotting items and bugs are in the foreground of the children's reflections and teachers' responses.

Excerpt 2

Teacher 1:	Well yes, what do we have here? Can you say, what we can find in the box? [The children explore the items in the box.]
Andy:	Oh, I don't want to touch it.
Teacher 2:	Did you find anything exciting? What do you think it is?
Lisa:	Oh, it is poop. [points at a rotten apple]
Teacher 2:	Is it poop?
Noa:	Who dares to touch it? [points at the rotten apple]
Teacher 2:	What is it?
Nils:	I don't dare hold it.
Teacher 1:	I can hold it, so you can see what it is. [picks up the rotten apple] Can you see? What is it?

Open-ended questions such as 'Well yes, what do we have here?', 'What do you think it is?', and 'Is there anything else?' are frequently used to encourage the children to discover and reflect on things found in the box. These open-ended questions lead the children in different directions as they discover and reflect on the contents of the box. The conversation in excerpt 3 illustrates how various parallel themes are addressed by the children and by the teacher.

Excerpt 3

Teacher:	What's that?
Mia:	There are some animals, insects!
Teacher:	Are there any animals there?
Mia:	Ah! There are more insects.
Teacher:	Where? Where?
Mia:	There!
Teacher:	Yes, what's that? [points into the box]
Peter:	A woodlouse! A woodlouse!
Teacher:	A woodlouse, yes. What does he do?
Simon:	He is sawing.
Anna:	You know, he is almost like a baby.
Teacher:	What do woodlice like to eat? Do you know?
Anton:	The babies are smaller.
Fred:	Apples.
Teacher:	Yes, they like apples, or they might like apples.
Fred:	They think it's candy.
Teacher:	Do they think it's candy? Yeah, perhaps, I can imagine that they think it's candy.
Mia:	There are a lot of insects.

In analysing how to approach and deal with the science-learning situation, this subcategory can be understood as the teachers' addressing more or less everything in which the children show interest. Different parallel themes are brought up by the children and many of them are taken into account, supported, and developed by the teacher. In that way, various parallel themes arise among the children during the session. Although not

all of them are evident in the above excerpts, these themes include: hunger and eating (favourite dishes), feelings (nervous, angry, happy), what woodlice do or do not like (darkness, dishes), ways to move around (running fast, woodlice can crawl up and down without falling off the stick), relationships with others (friends, family relations), fears and dangers (are woodlice dangerous?), counting and ordering by size, what smells bad and/or is disgusting, how the different objects feel (hard, soft, crumbly), pee and poo, and mould.

Some of the above themes are supported, encouraged, and developed by the teachers, but some are passed over without further comment, for example, when Simon in excerpt 3 talks about the woodlice 'sawing'. The category 'addressing everything' illustrates how the teachers focus on things that catch the children's interest and help the children reflect on and speculate whether or not these relate to the activity's focus on decomposition.

(Ac) *Addressing play and fantasy*. In this subcategory, teachers' approaches to science emphasise play and fantasy. The next excerpt illustrates a teacher-initiated situation intended to foster learning about what woodlice eat (project 3, Table 1). Teachers and children had put woodlice in different pots with different kinds of food (e.g. various kinds of leaves, soil, and moss). After several days, a group of 22 children aged 3–6 years and 3 teachers examined what might have happened in the pots. One teacher and one child (Anna) are taking a close look in one of the pots, leading to the following conversation:

Excerpt 4

Teacher:	Do they like each other, d'you think, the woodlouse and the worm?
	[There was also a worm in the pot.]
Anna:	Mm.
Teacher:	Imagine if they became pals, here in this pot, and played with each other.
Anna:	[silent, looking into the pot the teacher is holding]
	[The teacher turns the children's attention to the fact that there is a stick inside the pot.]
Teacher:	What is it for – practicing balancing, maybe?
Anna:	[looks and giggles]
Teacher:	Doing exercise maybe.
Anna:	Perhaps it wants to nibble the stick?
Teacher:	I think they like the stick. Better than leaves?
Anna:	Mm, leaves too.
Teacher:	What else do they do in the daytime?
Anna:	Perhaps they play a bit and nibble the leaves.

This teacher uses anthropomorphic speech to involve and challenge the children, which is why we refer this subcategory as 'addressing play and fantasy'. Anna is initially silent while the teacher continues to describe what might happen in the pot, though nothing is said about what woodlice eat. The teacher uses the children's everyday experiences as a frame of reference for discussing what woodlice do and how they live. By using anthropomorphic speech, the teacher keeps the conversation in an everyday context, adding no new knowledge to the learning situation. It is Anna who returns to the content initially agreed on, namely, what woodlice eat. The teacher's unilateral use of anthropomorphism means that the aim and science content – here, to learn what woodlice eat – ends up in the background.

(B) Creating a shared space for learning

This category contains an approach we interpreted as qualitatively different from those of the other category, as teachers' ways of dealing with science learning treat aspects of science as specific common content. Compared with the previous category, the intended learning object in this category stands out as intentionally concentrating on the featured science content.

(Ba) *Addressing common science content*. This is exemplified by a teacher-initiated situation intended to focus on ants' lives and involving five 4- to 5-year-olds and one teacher (project 4, Table 1). The children and teacher are walking across a meadow. They have visited the place previously, looking at ants, and now the teacher wants them to discern more aspects of the ants.

Excerpt 5

Teacher:	Now we have to see if we can find some ants. Do you remember where the anthill is? [The children run away to find the anthill.]
Kalle:	Look, we have found a lot of ants!
Teacher:	Oh there they are.
Pelle:	Here are a lot of them.
Pelle:	Look, they can fly!
Teacher:	Oh yes, they have got wings. Look. Carefully.
Kalle:	Some of them are moving.
Teacher:	Yes.
Pelle:	Wow so many, wow so many!
Teacher:	Yes, look they can fly away, making new colonies of ants.

The background to the above excerpt is that last time the teacher and the children visited the anthill, most of the children were not as familiar with ants as they were with, for example, spiders. The teacher then constituted an intended object of learning through touching on dimensions of variation. Critical aspects for making distinctions that the children could discern at that time were *how many legs* and *how many parts* do the ants have in contrast to spiders; at that time, those aspects constituted the enacted object of learning. When the teacher and children revisit the anthill, the teacher now directs the children's attention to the ants, encouraging and supporting them in their discoveries. She challenges the children and gives them opportunities to discern additional aspects of the ants, such as the facts that some ants can fly and that they live in colonies, which can be seen as aspects critical for generalising: all are ants even though some can fly and others cannot. On both occasions, the teacher concentrates on the object of learning, that is, what is to be learnt. In contrast to the other three subcategories, in this category, the teacher frames the situation by emphasising the featured science content, that is, what is to be learned. Such teachers encourage learning by using their knowledge of the science content and by listening to and supporting the children's curiosity so that children can discover increasingly subtle aspects of the learning object. In that sense, a shared space for learning about common content is created, contributing to a clarified learning object.

Discussion

This study aims to develop knowledge of ECE teachers' approaches to science-learning situations. According to Hundeide (2003), teachers are carriers of normative beliefs

about what constitutes good educational practice. The everyday actions of teachers are related to such overriding 'meta-contracts' and establish the frame for communication, for the content treated, and, in the end, for children's learning opportunities. We now want to highlight and discuss our results from two perspectives, namely *teachers as gatekeepers* (Thornton, 1989) and *teachers as border crossers* (Aikenhead, 1996).

Teachers as gatekeepers

Thornton (1989) argues that gatekeeping 'is educationally important because it determines both what content and experiences students have access to and the nature of that content and those experiences' (p. 6). We believe that teachers' normative beliefs cause them to act like gatekeepers. In the light of our results, it is interesting to reflect on the particular normative beliefs about ECE science learning of which these teachers could be bearers. Behind various approaches can be various meta-contracts, which in turn influence how the teachers interact with the children and address the featured content. Meta-contracts can concern 'good preschool practice', which in turn characterises the various approaches of the subcategories. Other meta-contracts concern the importance of every child's attention, or concern the fact that everything is worthy of notice or that play and fantasy are important in ECE. These meta-contracts tend to obscure the current learning object, here the featured scientific phenomenon.

Research results indicate that certain competences of teachers, such as subject knowledge and didactic insight, are important to children's learning about specific content (e.g. science content) (Cunningham et al., 2009; Nordenbo et al., 2008; Siraj-Blatchford et al., 2002; Thulin, 2011). Less often discussed is the significance of teachers' attitudes to children, content, and learning. Fleer (2009) studied a science-learning situation in preschool in which two adults (one a trained teacher and the other a teacher's assistant) were interacting with a group of children. Fleer's results indicate that it was the teacher's assistant who succeeded in interacting in a scientific way with the children. The reader may well ask, why? Fleer discussed this, arguing that the teacher's assistant had an open mind to science and no preconceptions about the children's ability to learn science or about what was possible in the context of preschool. The teacher – in contrast – was the bearer of assumptions that set the frame for what became possible in the situation. According to our study, comparisons can be made to the results relating to category A, *making anything visible*. In this category, the teacher's didactic approach helped keep the actual scientific phenomenon invisible to the children. Perhaps the teachers observed here consciously or unconsciously found it more important to maintain preconceptions than to make the content visible to the children.

Several researchers examining science learning in preschool have identified the risk that teachers may take children's learning for granted (see, e.g. Ärlemalm-Hagsér, 2008; Elm, 2008; Fleer, 2008; Sträng & Åberg Bengtsson, 2009; Thulin, 2006). In these researchers' studies, teachers ask questions and children are obliged to follow the teachers, observing and drawing their own conclusions in a kind of discovery learning (Siraj-Blatchford, 2001). The results of these studies also indicate that verbal communication is unilaterally linked to children's everyday experiences. Everyday life and daily usage are the norms and establish the frame for the learning situation, meaning that the content tends to be invisible to the children.

In our study, the results from category A (*making anything visible*) show the teachers responding to the children's expressions by striving to include all the children in something to do (subcategory Aa), by following anything they talk about (Ab), or by using anthropomorphic language (Ac). One aspect of this is that the intended science object of learning may be difficult for the children to discern and consequently learn about. The above discussion suggests that comparisons can be made with the present results. The teaching approach used in category A (*making anything visible*) tends to obscure the object of study. This can be described as the teacher's acting as a kind of gatekeeper, keeping out the featured science content and new knowledge. Unquestioned attitudes establish a frame for children's opportunities to learn. These attitudes, consciously or unconsciously expressed by the observed teachers, contribute to the gatekeeping syndrome.

Teachers as border crossers

In category B (*creating a shared space for learning*), we found a didactic approach opposite to those in category A. In category B, the object of learning became visible to the children. Given the purpose of science learning, one may ask what is so special about how the teacher dealt with the science situations in category B.

Pramling Samuelsson and Asplund Carlsson (2008) point out the need to consider children's perspectives when it comes to learning situations, to listen to the children's expressions and questions, and to create links to the featured content/object of learning. In such situations, teachers need to help children cross between well-known and unknown science content (Aikenhead, 1996). One can regard this teaching approach as a kind of simultaneous mutuality (Thulin, 2011; Thulin & Jonsson, 2014), simultaneous in that the teacher keeps both the child's perspective and the learning object in mind, mutual in that the teacher has a role in creating, by turns, teacher- and child-initiated communication. The teacher must keep the learning object in mind but also listen to the children, discern the meaning of the children's comments, and create challenges that direct the children's attention towards the learning object. The teacher must observe the interests of the children, creating framings of the situation by taking the children's ideas into account and by directing their attention towards the scientific content. In this way, the teacher creates a shared space of learning (Marton et al., 2004).

What ECE science can be in relation to the 'what perspective' has been discussed by several researchers (e.g. Eshach, 2006; Siraj-Blatchford, 2001). In this context, Eshach (2011) points out the need to involve children in collective science inquiry. Children should be allowed to observe, feel, discover, and put words to their experiences. Creating such learning environments is dependent on teachers who can provide children with efficient learning scaffolding. Research has identified teacher–child communication as important for children's learning (cf. Pramling Samuelsson & Asplund Carlsson, 2008). In category B, the teacher invited the children to look at and talk about the ants in various ways, applying words to the learning object. By using this style of communication, she helped the children cross the border between the well-known and the unknown. This kind of didactic approach implies that the teacher must possess appropriate content knowledge and scientific language (Cunningham et al., 2009).

When talking about children's learning, various figures of speech can be used. Regarding category A, we discussed various ways in which teachers can act as gatekeepers in relation to new knowledge. When discussing the results relating to category B, we described teachers as border crossers in relation to how they handled the object of learning. The teacher in category B can be said to have the ability to break new ground for the children, creating connections between the children's perspectives and the new knowledge in focus, helping the children cross the border between their everyday lives and the featured science content. Based on the present results, we emphasise, in line with Aikenhead (1996), the importance of the teacher's 'need to develop curriculum and instruction with these border crossings explicitly in mind' (p. 2).

Conclusion and implications

The aim of this research was to improve our knowledge of ECE teachers' approaches to science-learning situations. The study has examined the various ways teachers handle the object of learning, highlighting their various consequences by citing relevant examples. Our purpose here is not to talk about what is right and wrong in ECE science teaching, but to raise awareness of the complexity of the learning situation. Through our results, we demonstrate that teachers must be conscious of their attitudes to children's learning, of the featured content (here, science), and of their actions in relation to both the children's actual perspectives and the object of learning.

Teaching competence and content knowledge are of significance whether one is an ECE teacher or a teacher educator. Based on the present findings, we suggest large-scale research into teachers' approaches to ECE science learning, research that also takes account of children's responses to these approaches. Such research could deepen our knowledge of the conditions for science learning in ECE.

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References

Aikenhead, G. S. (1996). Science education: Border crossings into the sub-culture of science education. *Studies in Science Education*, *27*, 1–52.

Ärlemalm-Hagsér, E. (2008). Insikter om insekter – naturvetenskap i förskolan. In I. Pramling Samuelsson & N. Pramling (Eds.), *Didaktiska studier från förskola och skola* (pp. 67–81). Malmö: Gleerups.

Bruner, J. (1960/1996). *The process of education: A landmark in educational theory*. Cambridge, MA: Harvard University Press.

Cunningham, A. E., Zibulsky, J., & Callaghan, M. D. (2009). Starting small: Building pre-school teacher knowledge that supports early literacy development. *Reading and Writing*, *22*, 487–510. doi:10.1007/s11145-009-9164-z

Elm, A. (2008). *Interaktion och naturvetenskap i en förskola och en förskoleklass* [Interactions and science in preschool and preschool class]. Stockholm: Stockholm University, Department of Education.

Elstgest, J. (1999). Rätt fråga vid rätt tillfälle. In W. Harlen (Ed.), *Våga språnget! Om att undervisa barn i naturvetenskapliga ämnen* [Take the leap! On teaching children science subjects] (pp. 51–63). Stockholm: Liber.

Eshach, H. (2006). *Science literacy in primary schools and pre-schools*. Dordrecht: Springer.

Eshach, H. (2011). Science for young children: A new frontier for science education. *Journal of Science Education and Technology*, *20*, 435–443. doi:10.1007/s10956-011-9324-1

Fleer, M. (2008). Understanding the dialectical relations between everyday concepts and scientific concepts within play-based programs. *Research in Science Education*, *39*(2), 281–306. doi:10.1007/s11165-008-9085-x

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. doi:10.1080/09500690801953161

Fröbel, F. (1826/1995). *Människans fostran* [Die Menschenerziehung] (Översättning av Jan-Erik Johansson). Lund: Studentlitteratur.

Gustavsson, L., & Pramling, N. (2014). The educational nature of different ways teachers communicate with children about natural phenomena. *International Journal of Early Years Education*, *22*(1), 59–72.

Hansson, L., Löfgren, L., & Pendrill, A.-M. (2014). Starting from questions and everyday situations in preschool: What kind of science content could that lead to? *NorDiNa*, *10*(1), 77–89. Retrieved from https://www.journals.uio.no/index.php/nordina/article/view/634/771

Heikkilä, M., & Sahlström, F. (2003). Om användning av videoinspelning i fältarbete [The use of videorecording]. *Pedagogisk Forskning i Sverige*, *8*(1–2), 24–41. Retrieved from http://journals.lub.lu.se/index.php/pfs/article/view/7940/6994

Helldén, G. (1992). *Grundskoleelevers förståelse av ekologiska processor*. Kristianstad: Almqvist & Wiksell.

Hundeide, K. (2003). *Barns livsverden: Sosiokulturelle rammer for barns utvikling* [Children's life-worlds: Sociocultural frames for children's development]. Oslo: Cappelen.

Jonsson, A. (2013). *Att skapa läroplan för de yngsta barnen i förskolan: barns perspektiv och nuets didaktik* [Creating curriculum for the youngest children in preschool. Children's perspectives and didactics of the present moment]. Gothenburg: Acta Universitatis Gothoburgensis.

Karlsson Lohmander, M. (2004). The fading of a teaching profession? Reforms of early childhood teacher education in Sweden. *Early Years: An International Journal of Research and Development*, *24*(1), 23–34. doi:10.1080/0957514032000179034

Ljung-Djärf, A., Magnusson, A., & Peterson, S. (2014). From doing to learning: Changed focus during a pre-school learning study project on organic decomposition. *International Journal of Science Education*, *36*(4), 659–676. doi:10.1080/09500693.2013.822604

Ljung-Djärf, A., Mårdsjö Olsson, A.-C., & Thulin, S. (2013). Förskolans uppdrag. In M. Holmqvist Olander (Ed.), *Learning study i förskolan* [Learning study in early childhood education] (pp. 37–48). Lund: Studentlitteratur.

Marton, F. (1981). Phenomenography: describing conceptions of the world around us. *Instructional Science*, *10*(2), 177–200. doi:10.1007/BF00132516

Marton, F., & Booth, S. (1997). *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum.

Marton, F., Runesson, U., & Tsui, A. B. M. (2004). The space of learning. In F. Marton & A. B. M. Tsui (Eds.), *Classroom discourse and the space of learning* (pp. 3–40). Mahwah, NJ: Lawrence Erlbaum.

Ministry of Education and Science. (1998/2010). *Curriculum for preschool*. Lpfö98. Retrieved from www.skolverket.se

Nordenbo, S.-E., Søgaard Larsen, M., Tiftikçi, N., Wendt, R. E., & Østergaard, S. (2008). *Lærerkompetencer og elevers læring i førskole og skole. Et systematisk review udført for*

Kunnskapsdepartementet Oslo [Teacher competences and pupils learning in preschool and school. A systematic review conducted for Kunnskapsdepartementet Oslo]. Dansk clearinghouse for uddannelseforskning. Copenhagen: Danish School of Education.

Pramling, I. (1994). *Kunnandets grunder: Prövning av en fenomenografisk ansats till att utveckla barns sätt att uppfatta sin omvärld* [The basic of knowledge. A phenomenografic approach to develop children's conceptions of the world]. Gothenburg: Acta Universitatis Gothenburgensis.

Pramling Samuelsson, I., & Asplund Carlsson, M. (2008). The playing learning child: Towards a pedagogy of early childhood. *Scandinavian Journal of Educational Research*, *52*(6), 623–641. doi:10.1080/00313830802497265

Sheridan, S. (2001). *Pedagogical quality in preschool: An issue of perspective*. Gothenburg: Acta Universitatis Gothoburgensis.

Sheridan, S., Pramling Samuelsson, I., & Johansson, E. (2009). *Barns tidiga lärande: en tvärsnittsstudie om förskolan som miljö för barns lärande* [Children's early learning. A cross sectional study on the preschool as an environment for children's learning]. Gothenburg: Acta Universitatis Gothoburgensis.

Siraj-Blatchford, I., Sylva, K., Muttock, S., Gilden, R., & Bell, D. (2002). *Researching effective pedagogy in the early years* (Research report RR356). London: University of London, Institute of Education.

Siraj-Blatchford, J. (2001, July/August). *Emergent science and technology in the early years*. Paper presented at the XXIII World Congress of OMEP, Santiago, Chile.

Siraj-Blatchford, J., & MacLead-Brudenell, I. (1999). *Supporting science, design and technology in the early years*. Buckingham: Open University Press.

Sträng, M., & Åberg Bengtsson, L. (2009). 'From the mountain and then?' Five-year-olds visiting the 'way of the water' exhibition at a science centre. *International Journal of Early Childhood*, *41*(1), 13–31. doi:10.1007/BF03168483

Swedish Research Council. (2011). *Forskningsetiska principer inom humanistisk-samhällsvetenskaplig forskning* [Ethical principles in social science research]. Retrieved from http://www.ibl.liu.se/student/bvg/filarkiv/1.77549/Forskningsetiska_principer_fix.pdf

The Swedish Schools Inspectorate. (2012). *Skolinspektionens rapport 2012:7 Kvalitetsgranskning. Förskola, före skola – lärande och bärande* [Quality review 2012:7. Preschool, before school – learning and supporting]. Stockholm: Swedish Schools Inspectorate.

Sylva, K., Melhuish, E., Sammons, P., Siraj-Blatchford, I., & Taggart, B. (2010). *Early childhood matters: Evidence from the effective pre-school and primary education project*. Abingdon: Routledge.

Thornton, S. J. (1989, March). *Aspiration and practice: Teacher as curricular-instructional gatekeeper in social studies*. Paper presented at the 70th annual Meeting of the American Educational Research Association, San Francisco, CA, USA.

Thulin, S. (2006). *Vad händer med lärandets objekt? En studie av hur lärare och barn kommunicerar naturvetenskapliga fenomen* [What happens to the object of learning? A study of how teachers and children in preschool communicate scientific phenomena; in Swedish]. Växjö: Växjö University Press.

Thulin, S. (2011). *Lärares tal och barns nyfikenhet. Kommunikation om naturvetenskapliga innehåll i förskolan* [Teacher talk and children's queries. Communication about natural science in early childhood education]. Gothenburg: Acta Universitatis Gothoburgensis.

Thulin, S., & Jonsson, A. (2014). Child perspectives and childreńs perspectives – A concern for teachers in preschool. *Educare*, *2*, 13–37.

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. doi:10.1080/09669760902982331

Uljens, M. (1989). Fenomenografin, dess icke-dualistiska ontology och Menons paradox. *Pedagogisk forskning i Sverige*, *3*(2), 122–129.

Yoshikawa, H., Weiland, C., Brooks-Gunn, J., Burchinal, M. R., Espinosa, L. M., Gormley, W. T., … Zaslow, M. J. (2013). *Investing in our future: The evidence base on preschool education*. In Society for Research in Child Development. Retrieved from http://fed-us.org/resources/evidence-base-preschool (hämtat den 2016-03-13)