Opportunities for Education for Sustainability through multidimensional preschool science

Abstract
In this article, we exemplify and discuss how preschool science education may contribute to Education for Sustainability (EfS). We draw on data from science activities in fourteen Swedish preschools, in which we have previously identified examples of ‘multidimensional science teaching’, hence, teaching that intertwines children’s science learning with multiple dimensions of children’s lives, such as emotions, fantasy, play and aesthetic modes of expressions. By re-analysing these activities through an EfS lense, we show several examples of how multidimensional science teaching provide opportunities for children to develop agency and empowerment as well as connectedness with the environment, and some examples of creative problem solving. Yet, we advocate that teachers’ active participation is crucial for realising multidimensional science teaching in a way that contributes to EfS.

INTRODUCTION
There is a general agreement that we need to shift our thinking and acting from the anthropocentric view towards realising that our lives are intertwined with the ecosystems of our planet. To achieve such a shift, it is crucial to ‘empower individuals to reflect on their own actions, taking into account their current and future social, cultural, economic and environmental impacts, from a local and a
According to UNESCO (2017), Education for Sustainability (EfS) is seen as integral for a change towards a sustainable society. Attempting to guide policy-makers as well as educators, UNESCO has suggested learning objectives and cross-cutting key competences important to consider when designing EfS. These key competences are based on research on higher education and are not fully compatible with EfS in early childhood. Still, in line with current policies, contemporary research on EfS in early childhood advocate that children are viewed as active participants in social contexts (Gothenburg Environmental Centre, 2010) and agents for change (Caiman & Lundegård, 2014; Blanchet-Cohen, 2008; Davies, 2015). A review made by Hedefalk, Almqvist, and Östman (2015) exposes a lack of articles that deal with empirical studies of early childhood EfS, as it shows that a majority of the articles in the field are theoretically oriented. With the current article, we seek to contribute an empirically grounded analysis of how preschool science activities can contribute to EfS. The article builds on data gained in a study of science activities in fourteen preschools, which gave us numerous examples of creative and inclusive ways of shaping science learning opportunities for children (Sundberg et al., 2018). We noted that the teachers intertwined science learning with fantasy, play, embodiment, empathy, aesthetic modes of expression, storytelling and systematic inquiry (Areljung & Sundberg, 2018). This plurality and complexity, which is characteristic for preschool teaching, is captured by the term ‘multidimensional teaching’, where the teaching of science content is intertwined with multiple dimensions of children’s lives, such as, emotions, play, and physical experiences (Klaar & Öhm, 2014; Areljung & Sundberg, 2018). Foreseeing that multidimensional science teaching can make way for the competencies advocated in contemporary EfS research and policy, we will, in this article, revisit our data with the aim to explore how science education may contribute to Education for Sustainability in preschool.

**EfS in early childhood**

One goal of EfS is to develop action competence (cf. Jensen & Schnack, 1997), which for preschool pedagogy implies that teachers create conditions for children to take actions (Chawla & Cushing, 2007), to make their voice heard, and to understand that there are alternative ways to act (Caiman & Lundegård, 2014; Hedefalk, Almqvist, & Lidar, 2014). Teachers may accomplish such pedagogy by introducing children to the process of inquiry, and by inviting them to be part of the knowledge production. Based on an analysis of preschool inquiry activities, Andersson and Gullberg (2014) have discussed that children’s power of their own learning, and personal experiences of knowledge production, is integral for promoting their self-confidence in science as well as in other areas, thereby laying a foundation for ‘a certainty that she/he can deal with difficulties in other situations and develop self-reliance’ (p. 292). In contrast, Ärlemalm-Hagsér’s (2013b) study of preschool teachers’ views of their own EfS practice, shows that teachers describe children’s participation in terms of ‘taking part in’ activities rather than as being active participants. Another goal of education for sustainable development is to strengthen children’s sensation of being connected with the society and with the environment (Blanchet-Cohen, 2008; Chawla, 1998). Blanchet-Cohen (2008, p.257) states that children’s involvement with the environment is both a goal in itself, and ‘a means for children to explore and to define themselves in relation to others’. Moreover, the ability to use imagination, to be creative and to ‘think outside the box’ or ‘strike out in new directions’ is often put forward as key competences when dealing with the complexity and uncertainty of sustainability challenges (Caiman & Lundegård, 2018; Sandri, 2012, UNESCO 2017).

**The Swedish context**

Our empirical examples stem from Swedish preschool practice. The national preschool curriculum includes fundamental values and tasks related to EfS, for example, that preschool should support children to create positive images of themselves as learners and creative individuals (National Agency for Education, 2011, 2018). At the time of data gathering, the curriculum stated that the preschool should emphasise issues concerning the environment and nature conservation (National Agency for Education, 2011). Recently, the curriculum was revised, resulting in a more explicit focus on EfS, and it now says that the preschool should ‘provide each child with the conditions to develop a growing responsibility for and interest in sustainable development and active participation in society’ (National
Agency for Education, 2018, p.13). When it comes to EfS in practice, Sweden joins the international pattern of mainly providing teaching in and about nature (see Davis, 2009; Hedefalk et al., 2015). Research shows that Swedish preschool EfS has rested on a strong belief in nature experiences as fundamental to a lifelong commitment to the environment (Ärlemalm-Hagsér, 2013a). The practice has been, and is still, dominated by nature encounters and recycling activities (Ärlemalm-Hagsér & Sundberg, 2016). Kultti and colleagues point out that Swedish preschool teachers often have difficulties in handling EfS, especially teaching that includes a holistic, transformative approach (Kultti, Ärlemalm-Hagsér, Larsson, & Pramling Samuelsson, 2016).

**METHOD: REVISITING DESCRIPTIONS OF MULTIDIMENSIONAL PRESCHOOL SCIENCE TO IDENTIFY POTENTIAL FOR EFS**

This study is positioned within a larger project where Activity Theory (AT) was used as a theoretical framework to analyse general patterns for how cultural and historical factors interact with the shaping of science activities in preschools. In accordance with AT (Engeström 1987) we have, for each science activity, produced thorough descriptions of the subject, object, tools, rules, community, division of labour and outcome of the activities (Sundberg et al., 2016, 2018). These descriptions form the basis of the analysis presented herein.

**Empirical data**

Our empirical material builds on observations of science activities in fourteen preschools, whose teachers had expressed that science activities were a common feature of practice. Each preschool was visited on four to ten occasions (97 in total) and afterwards the preschool’s team of three to five teachers participated in a stimulated recall discussion, where researchers presented glimpses from field notes and videos. Our data gathering focused on teachers’ actions, their views of science education, and what science learning opportunities they afforded to the children. Hence, the data allow us to empirically examine if multidimensional science teaching can make way for some of the key competencies advocated in contemporary EfS research and policy, but not whether the children actually develop any of the competencies.

**The analytical process**

Initially, we singled out three overarching EfS themes, advocated in contemporary research and policy, to guide our analysis: ‘Agency and empowerment’ (Caiman & Lundegård, 2014; Hedefalk, Almqvist, & Lidar, 2014), ‘Connectedness to the environment’ (Blanchet-Cohen, 2008; Chawla, 1998), and ‘Creative problem solving’ (Caiman & Lundegård, 2018). We note that these themes may encompass multiple meanings, which are not always explicitly specified in research reports, and that there is no general consensus as to what these themes include or implicate. Especially the description of agency has different theoretical underpinnings, and can as in Blanchet-Cohen’s study (2008) include different dimensions, for example, connectedness, engaging with the environment, questioning, belief in capacity, taking a stance, and strategic action. We do not delve into the discussion here, but for the sake of our analysis we consider agency as a person’s capacity to act in a specific situation; empowerment as a process of being strengthened in one’s confidence and authority; connectedness as the experiences of feelings linked to nature and environment; and creative problem-solving as the process of handling issues in ways that are new for the individual.

Our next step was to determine which of the themes that applied to the different preschool science activities. For each activity where an EfS theme was applicable (in some activities more than one theme was applicable), we also identified what teaching dimensions (fantasy and play, empathy, ethics and moral issues, embodiment and sensory experience, aesthetic modes of expression, storytelling, and systematic inquiry) that were part of that activity. Furthermore, we identified the teacher’s role in the activity, and what kind of science learning opportunities the activity entailed (see Table 1).
**FINDINGS**

Looking across the fourteen preschools, we find that they all provided multidimensional science teaching, but some did not provide clearly framed opportunities for either EFS or science learning. Some preschools were characterised by a consensus among the teachers that children’s interests should guide practice. Hence, science learning was voluntary (cf. Sundberg et al., 2018). In these preschools, the teachers held back on active guidance, leaving the children to make connections between activities and planned learning object, which made both the science learning object and the potentials for EFS elusive. In most preschools however, we see that the multidimensional science activities may contribute to EFS. In the following sections, we present stories from two of the preschools to show how they have shaped their multidimensional science teaching and how such teaching can contribute to EFS. These two preschools were selected because their work with science encompasses all three EFS themes and all the teaching dimensions described above. Together they also cover the whole range of preschool children’s ages, including the youngest children, which is rare in research on science education and EFS in early childhood; ‘The Magpie Preschool’ is for children aged 1-2 years and ‘The Fungus Preschool’ is for children aged 2-5 years. The two preschool stories are followed by a table, which illustrates how different teaching dimensions can be connected to the teacher’s role and to opportunities for EFS as well as for science learning (Table 1).

**Story 1: The Magpie preschool**

Characteristic for the ‘Magpie Preschool’ was their structured way of working with inquiry, something they managed even though the children were very young, aged 1-2 years. According to the four teachers working there, it is important to recognise and extend the discoveries that emerge in children’s encounters with their surrounding world. In this preschool, where little of the children’s communication was verbal, we noted that the teachers were attentive to how children showed their interests, questions, explorations and conclusions by the way they moved, what they pointed at, and where they directed their gaze. Moreover, the teachers expressed that children need help to navigate in the multi-sensory noise that they are in, at the preschool as well as in the forest. Therefore, they sometimes guided children to focus on only one sense at a time. For example, they encouraged children to touch the moss on a stone, sensing its texture against their hands and cheeks. During one of our visits, we observed that the teachers asked children to use primarily their hearing to register somebody walking on snow: Was the creaking sound of the teacher’s steps different from the sounds of one of the children treading on the snow?

Every week, the teachers and children walked to a particular place in a nearby forest. From what we saw during our visits, the teachers managed to make inquiry-based learning experiences out of unforeseen events. On one occasion, they brought a box to the forest in order to have a storytelling moment out there. The box contained figures connected to a story about a child going on a sleigh on an icy lake. While telling the story, the teacher placed the figures on a woolen blanket, including a plastic snowman and a snowman that she made out of real snow. When the teacher collected the figures to put them back in the box, she noticed that the ‘real’ snowman stuck to the blanket. Since she realised that this was something special, she demonstrated several times that the ‘real’ snowman stuck and the plastic snowman did not stick. She then asked the children for suggestions on other things that might stick. One child suggested ‘moss’ and before the teacher tested the stickiness of moss she asked each child if they thought it would stick or not (it did not). Out of this sequence, we identify several aspects of systematic inquiry, such as making predictions and systematic comparisons.

During another visit to the forest, the children left some of their sandwiches on the ground and later they noticed birds enjoying the sandwich leftovers. The event sparked a theme work focusing magpies. Seeking to make a model of the magpie’s nest, the teachers and children watched different pictures of birds’ nests and then a teacher assisted groups of children to add sticks to a form made of chicken wire, while she talked with the children about ‘how the magpie would like its nest’. Further, the theme included several drama and play activities in which teachers and children walked, flew and ate like magpies. On one occasion, a teacher played the role of the magpie, emphasising with her voice...
and body language that she was sad and lonely. Engaging in this play and drama activity, many of the children approached the teacher/magpie, giving her a hug. According to the teacher, they showed a type of affection that she had never seen them do before. The children also made paintings of magpies and the teachers drew on the different magpie pictures to discuss and exemplify diversity and equal value with the children.

**Opportunities for EfS in the Magpie preschool**

In the multidimensional science activities of the Magpie preschool, we see several examples of how science education may contribute to EfS. The teachers emphasise that the children’s views, voices and interests are valued, which is an important ground for fostering agency and empowerment. For example, the teachers first observe what the children recognise and discover in their encounters with their surrounding world. They then extend the children’s interests into organised science themes. In addition, they organise small scale inquiries, where science phenomena are carefully observed and explored through different senses, one at a time. Thereby, these very young children gain experiences of making observations and asking questions about the objects, organisms and processes they meet in nature. During the process of making inferences of the observations, the teachers also seek to give the children a voice, even though sometimes not verbal.

The careful investigations and embodied experiences provide opportunities to learn about the environment, but also to connect to the environment through empathy and imagination. For example, dimensions like fantasy, play and storytelling are used as a means for learning about how the magpie lives. At the same time, these dimensions contribute to opening up for a discussion about feelings such as loneliness and thus an opportunity to practice empathy and philosophise about possible emotions of other organisms. Another example of how multidimensional science teaching may make way for EfS is how the teachers make use of aesthetic modes of expression. Here, the arts activities ignite discussions about diversity and equality. They also provide opportunities to wonder, learn and communicate about the nesting preferences of another organism.

**Story 2: The Fungus preschool**

The Fungus preschools catered for children aged 2-5 years. In this preschool it was key to the three teachers that the science learning activities build on, and support, children’s interests and questions, and that they include practical and aesthetic activities. In one of their trips to the forest, a group of children noticed that fungi grew on some of the trees. They named one of these fungi ‘Musli’ and over a long period of time, the children and their teachers developed an imaginary world around the life of Musli and his relatives. The children connected to the fungus as a friend to care for. For example, during one trip to the forest in late autumn, the children were worried that Musli might be cold when the winter arrived, so for the next trip they brought clothes to dress the fungus. During a group interview, the preschool teachers also described an incident where they had to withdraw a suggestion to cut one fungus down to take it back to the classroom for closer observations. The reason was that the idea of cutting fungi off trees was perceived by the children as a cruelty to Musli and his relatives.

The teachers discussed how they could build on the children’s engagement to introduce content learning about fungi in a way that also allowed them to keep their fantasies about Musli as a friend. They decided to start a conversation between the children and Musli through letters. The first letter was written to draw the children’s attention to how tree fungi get nutrition, attempting to create engagement by mirroring fungi’s need of nutrition to the children’s need of food. The teachers placed a letter ‘from Musli’ on Musli’s tree for the children to find. In the letter Musli asked what and how the children ate. The children wrote back that they liked cake and asked if that also was the case for Musli. Because the children’s attention was drawn to the nutritional needs of the fungus, they started a discussion about how and what fungi might eat. They tried to treat Musli to a banana, which led them to the observation that Musli did not have a mouth. In coming occasions, the teachers’ described to the children how fungi like Musli inject thin threads into the trunk of the tree they are living on, and that nutrients are transported from the tree to the fungus through these threads. The correspondence so
continued throughout the fall where the children and Musli took turns in asking and answering questions from each other.

Indoors did the teachers employ several other approaches to draw children’s attention to the details of the fungus, and its relation to the tree. Following up on the question of how Musli got his food, the teachers helped the children to roll a big piece of paper into a cylinder form, making room for as much as three children on the inside. Sitting inside the tree, the children could draw directly on the cylinder-shaped paper what they thought the inside may look like. Hence, they created a model of a tree trunk, illustrating the pipeline where water and sugar compounds are transported between leaves and the roots. The children were also invited to use magnifying glasses to study fungi more closely, and each child made its own fungus in papier-mâché. If they chose to make the fungus in a shape or colour to their own liking they were allowed to do so.

**Opportunities for EfS in The Fungus preschool**

Just like in the Magpie preschool, the teachers of the Fungus preschool create an atmosphere where children’s thoughts, interests and suggestions are seen as important ingredients when reasoning and learning about science. Thus, they are creating opportunities for the children to develop self-confidence, an important ingredient in agency and empowerment. The emergent imaginary world of Musli and his relatives, initiated by the children, is seen as an asset, not a problem. Instead of rejecting the children’s ideas as unscientific, the teachers integrate the children’s fantasy with the science theme by for example initiating a mail correspondence where life conditions for a fungus and humans are compared. Moreover, the teachers’ generous interpretation of what fits into a science theme opens up for solving problems, identified by the children, such as how to comfort a freezing fungus. This problem is taken seriously and acted upon, which is another example of how these teachers encourage empowerment, agency and problem solving.

In the Fungus Preschool, the children are given opportunities to connect to, and learn about, the environment through several different aesthetic modes of expressions. The scientific part of the fungal theme is explored through drawing and making models, where the children are encouraged to pay attention to connections, differences and details of trees and fungi. However, fantasy is also a welcome dimension in these drawings and models, which helps children to participate on their own terms. The children develop a friendship to the fungus, and the teachers acknowledge the empathy and moral dimensions of the friendship, which opens up for discussions on issues such as respect for other living creatures. There are rather few activities where moral issues were identified in our material overall, but when there are, we see examples of teachers conveying rules such as ‘do not break the branches off the tree’ or ‘do not step on the mushrooms’. We also identify examples where teachers show an open attitude to the children’s different suggestions, but then again, these can be said to fall within a caring frame, such as the suggestion to dress the fungus and the plea to not cut the fungus off the tree. From our point of view, the multidimensional science teaching of the Fungus preschool gives many opportunities for the children to develop science knowledge as well as connectedness with nature and experiences of agency and creative problem solving.

**Relations between teaching dimensions and opportunities for EfS**

In this article, we have revisited multidimensional science activities of 14 preschools to empirically explore how preschool science education may contribute to preschool Education for Sustainability. Multidimensional science activities encompasses teaching dimensions such as fantasy and play, empathy, ethics and moral issues, embodiment and sensory experience, aesthetic modes of expression, storytelling, and systematic inquiry. Our analysis shows that the intertwinement of one or many of these dimensions may contribute to EfS as well as to science education. In table 1 we illustrate how each of these dimensions can give opportunities for EfS and science learning by providing examples of activities where the dimension is included, and the teacher’s role in these activities.
Table 1. Examples of the link between teaching dimension, the teachers’ role, and the opportunities for education for sustainability (EfS) and for science learning.

| Teaching dimensions | Examples of activities | Opportunities for education for sustainability (EfS) | Opportunities for science learning |
|---------------------|------------------------|----------------------------------------------------|----------------------------------|
| Agency and empowerment | Mail correspondence about what the fungus likes to eat. Treating the fungus to a banana. | Mail correspondence about what the fungus likes to eat. | Telling the story and using snow figures to illustrate 'stickiness'. |
| Play | Fantasizing about what it is like to move like a bird. | Fantasizing about what it is like to move like a bird. | Fantasizing about what it is like to move like a bird. |
| Empathy | Helping children to focus on one sensory input at a time. | Helping children to focus on one sensory input at a time. | Helping children to focus on one sensory input at a time. |
| Ethics and moral issues | Including the task, assisting children practically, drawing attention to the bird's needs. | Including the task, assisting children practically, drawing attention to the bird's needs. | Including the task, assisting children practically, drawing attention to the bird's needs. |
| Storytelling | Sensing the moss on a stone. Listening to the sound of walking on snow. | Sensing the moss on a stone. Listening to the sound of walking on snow. | Sensing the moss on a stone. Listening to the sound of walking on snow. |
| Embodiment and sensory experiences | Providing material, involving the fungus as an observational model for knowledge production. | Making model (e.g., a tree trunk and a fungus). | Making model (e.g., a tree trunk and a fungus). |
| Aesthetic modes of expression | Drawing inside of a tree trunk on convoluted paper. | Drawing inside of a tree trunk on convoluted paper. | Drawing inside of a tree trunk on convoluted paper. |
| Systematic inquiry | Investigating what figures that stick to a wooden bracelet. | Investigating what figures that stick to a wooden bracelet. | Investigating what figures that stick to a wooden bracelet. |
For example, reading the first row in the table, we posit that ‘fantasy and play’ is a teaching dimension in the activity where children write a letter to the fungus Musli to ask about his eating habits. Here, the teachers seek to draw children’s attention to the issue of how fungi and humans eat. At the same time, they acknowledge the children’s fantasy by taking on the role of writing the fungus’s letters. In terms of EfS, the activity provides opportunities to connect to other living species through fantasy and play, by focusing on the fact that fungi need to ‘eat’, just like humans do. Furthermore, it provides opportunities for children to develop agency since it is their own observations and questions, part of which they have printed on a letter, that form a basis for the knowledge produced about how fungi eat. In terms of science learning, the activity provides opportunities to learn about how fungi ‘eat’ and to compare and contrast the nutritional needs of fungi and humans.

DISCUSSION

Overall, our results suggest that preschool teachers’ multidimensional way of investigating the surrounding world together with the children, herein illustrated by the practices of the Fungus Preschool and The Magpie Preschool, aligns well with the pedagogy often advocated in EfS research (e.g., Davis, 2015; Caima & Lundegård, 2014, 2018; Blanchet-Cohen, 2008). First, we have shown examples of science activities that make way for Agency and empowerment, since teachers take children’s voices, interests, and questions seriously and support children to guide their own learning. Second, our results illustrate that teachers invite children to strengthen their Connectedness to the environment through fantasy and play, empathy, ethics and moral issues, embodiment and sensory experiences and aesthetic modes of expression and systematic inquiry. Third, even though they are few, we provide some examples of science activities that open up for Creative problem solving as teachers encourage children to identify challenges and solutions in playful situations, sometimes by using fantasy and play, empathy and aesthetic modes of expression. Below, we discuss our results in relation to research concerning these three EfS themes.

Agency and empowerment

One goal that is advocated in both EfS research (Hedefalk et al., 2015) and policy (Gothenburg Environmental Centre, 2010; UNESCO 2017) is to empower children and invite them to be active participants in social context. In our examples, we see that teachers provide inquiry activities where the children are allowed to be active agents in their investigations of the surrounding world. In many cases, these activities also make room for dimensions such as fantasy, play, empathy, ethics, and embodiment. This is in accordance with the type of preschool inquiry activities that Andersson and Gullberg (2014) put forward as integral for promoting children’s self-confidence and self-reliance. Yet, our examples provide a contrast to a study showing that in preschool teachers’ descriptions of their own EfS, children’s participation is presented in terms of merely ‘taking part in’ activities (Ärlemalm-Hagsér, 2013b). Our results contribute to a broader picture of how children may gain personal experiences of knowledge production. It is not only a matter of inviting children to pose questions, investigate in practice and draw conclusions, but also a matter of using ‘a child’s whole being, mind and body’ in the process of producing knowledge (cf. Westman & Bergmark, 2014, p.78). We therefore posit that science activities where the children are allowed to be active agents may be one way for preschool teachers to empower children.

Connectedness with the environment

Another goal of education for sustainable development is to strengthen our sensation of being connected to the world and the nature, rather than feeling as spectators, detached from the natural world (cf., Colucci-Gray, 2017; Østergaard, 2017). The children in our study are provided with plenty of opportunities to strengthen their connectedness with the environment. In both preschools described, children are sometimes left to explore and play in the forest at their own choice, but often the teachers guide them towards clearly articulated science learning objects. For example, in the Magpie Preschool, the children are encouraged to pay attention to the stickiness of different materials and the
teachers help the children to focus on one sensory impression at a time when investigating objects and connections in nature. In both preschools, the teachers also provide opportunities for learning about other organisms and ecological relationships through non-traditional (from a science teaching point of view) dimensions such as empathy, fantasy, aesthetic expressions, embodiment and storytelling - activities that also give opportunities to identify, and care for, other organisms. From an EfS point of view, we see that the teachers’ ways of using teaching dimensions such as empathy, fantasy and play may promote children’s connectedness to the environment. Their inclusive way of teaching also opens up to discussing moral issues and respect for living organisms. This is in line with other studies showing that personal emotions and values may serve as a starting point for making meaning and in the longer run for making value judgements in environmental and sustainability issues (Manni, Sporre, & Ottander, 2017; Fleer, 2013). However, we recognise teachers’ crucial role in balancing between a normative route where pre-defined values are put forward, and an explorative route where different views are allowed and the children are in charge of coming to conclusions (cf. Hedefalk, Almqvist, & Lidar, 2014).

Creative problem solving
Creative problem solving is identified by UNESCO as one of the key competences that learners of all ages needs to develop, describing it as ‘the overarching ability to apply different problem-solving frameworks to complex sustainability problems’ (UNESCO, 2017, p.10). When it comes to preschool practice, Hedefalk et al. (2015) indicate that it is rare that children are asked to explore different ways of dealing with sustainability problems. Our results show some, but not many, examples where children are invited to use their imagination and to express their knowledge, feelings and thoughts through aesthetic modes of expression in the process of solving problems. For example, children are allowed to create a fantasy world around the fungus Musli, in which they identify problems and try to solve them to help Musli. Even though our examples are few, we posit that this way of making room for a mix of children’s fantasy and experiences can foster a creative teaching environment for solving complex problems. Examples of such teaching is displayed in a study where Caiman and Lundegård (2018) invited children to solve problems related to sustainability issues in their own ways. Caiman and Lundegård argue that the children’s solutions contribute to society by widening conventional ways of thinking. They also recognise that the solutions suggested by the children might be rejected by adults who consider them as naïve or not possible to implement. Furthermore, Elfström (2013) has shown how children’s mixing of fantasy and reality might give new insights and ideas for further investigations of phenomena in nature. Elfström also showed that children need guidance from teachers with competence in science to extend their investigations, which is in line with the results in our study.

CONCLUSION AND IMPLICATIONS
We conclude that multidimensional science teaching may connect with important themes in EfS; agency and empowerment, connectedness with nature and creative problem solving. Hence, this study shows that multidimensional science education in preschools does have the potential to provide the forms of education often advocated in contemporary EfS research (Hedefalk et al., 2015) and policy (UNESCO, 2017). We also conclude that the teacher’s role is crucial for if, and how, multidimensional teaching may contribute to EfS.

When it comes to EfS, a debated issue is if children will develop nature connectedness merely by being in nature (Sandell & Öhman, 2010), and automatically act for change if they learn facts about plants, animals and ecological processes (Hedefalk et al., 2015). Correspondingly, research has shown that preschool children often are left to explore and play at their own choice, as preschool teachers often presuppose that children will develop science learning by experiencing nature (Fleer, 2009a; Halldén, 2009). In contrast, adult guidance is advocated by researchers as a cornerstone for children’s possibilities to make meaning of their experiences in nature (Inan, Trundle & Kantor, 2010; Nayfeld, Brenneman & Gelman, 2011; Gustavsson et al., 2016). We acknowledge that there are ben-
efits for children to ‘just be in nature’ (cf. Sandell & Öhman, 2010), but question the idea of unguided
time meetings as a foundation for science learning and EfS. When describing the three EfS themes
in relation to preschool activities, we have therefore emphasised the importance of a teacher that
takes a guiding role during activities. Our study is thereby a contribution to the research discussion
about the teacher’s role for children’s learning in both EfS and science education.

Our results describe creative and inclusive ways of shaping science learning opportunities for children
by opening up for mixing teaching of science content with imaginary situations. We also describe
teaching where the teachers’ and children’s communication is anthropomorphised, transferring their
human experiences to the life of the fungus. Research has reported on the difficulty of ‘leading the
children back’ to a specific content once an imaginary situation has been created (Fleer, 2009b; Thu-
lin & Pramling, 2009). In addition, anthropomorphism in preschool science has been problematised
as it might lead to a human-centered view of nature (Thu麟lin & Pramling, 2009). Yet, our examples
show that imaginary experiences and anthropomorphism also make way for science knowledge. For
example, the children’s attempt to treat the fungus to a banana draws their attention to the fact that
organisms other than humans may have different prerequisites for living, as in this case; the fungus
does not have a mouth and must get its food in some other way. This in turn makes them observant of
differences in nutritional needs of different types of organisms.

Finally, research has shown that many Swedish teachers have difficulties when it comes to teaching
for sustainability (Kultti et al., 2016). Another study indicates that teachers with EfS training are
more likely to work in a broader, and more active, way with EfS, for example, conducting projects
related to the surrounding society and the social and economic dimensions of sustainable develop-
ment (Arlemalm-Hagsér & Sundberg, 2016). Our results exemplify how preschool science may give
opportunities for developing preschool EfS and we propose that these examples can be used in pre-
and in-service training when discussing what teaching for agency, empowerment, connectedness to
the environment and creative problem solving can be in practice involving young children.

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