Opportunities for and obstacles to science in preschoo.

views from a community perspective

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ABSTRACT
In this study, Activity Theory (AT) is used to analyse general patterns for how cultural and historical factors interact with the shaping of science activities in preschools. Data was produced from field notes, video observations, video stimulated recall group discussions and individual interviews with preschool teachers at fourteen preschool units, where science activities were described as a common feature of the practice. Two factors were found to be particularly important for how and whether science learning opportunities were afforded the children: the structure of the preschool community and the type of educational culture within it. In communities characterised by weak mutual commitment and without joint understanding of the purpose of the activities, the science learning objects of the activity often became fragmented and thereby elusive. This was also true for strong communities, with a shared approach and a joint understanding of the purpose of the science activities, but with educational cultures where science learning was not actively supported. In contrast, a strong community combined with an educational culture that allowed teachers to lead and intentionally frame the science content, offered child-centred science activities with clear science learning objects.

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Introduction

As in many other countries, Swedish preschools are currently moving towards an early childhood education that places more emphasis on learning specific subjects. The greater emphasis on science teaching in the preschool has given rise to questions about how to shape preschool practices in ways that provide for science learning. These questions are urgent, especially as research has reported on problems in implementing science teaching in preschools, many of which are connected with preschool teachers’ attitudes towards science, their lack of science skills and their lack of confidence in teaching the subject (e.g. Garbett, 2003; Spector-Levy, Kesner Baruch, & Mevarech, 2013). The increased emphasis on science teaching has also generated theoretical and ideological
discussions about what science in preschool can or should be. For example, Siraj-Blatchford (2001) has suggested that the early learning of science needs a new curriculum that accepts the diversity of children’s experiences, interests and development. He has also suggested the term emergent science to emphasise the differences between preschool science and school science. In line with Siraj-Blatchford, Johnston (2008) argues for the promotion of children’s scientific skills, attitudes, understandings and language through shared investigations. New perspectives on the teacher’s role and that of the whole preschool community in science activities have also been discussed (Fleer, 2009; Sundberg & Ottander, 2013). Despite this, very few studies have explored the diversity of science activities that take place in preschools today, the factors that affect the different pedagogical choices of the preschool staff, and the outcomes in terms of science learning opportunities afforded to the children.

The study presented here builds on a previous study in which Activity Theory (AT) was used to explore how cultural factors in three preschools interacted with the teachers’ shaping of science-related activities (Sundberg, Areljung, Due, Ekström, Ottander & Tellgren, 2016). That study showed that the children were provided with interesting and inclusive activities that matched the overarching goals of the Swedish curriculum for the preschool (National Agency for Education, 2011). However, a relatively prominent feature was an elusiveness of the intended science learning object due to the prioritisation of other objectives. The results suggested that the degree of ‘science object elusiveness’ could be connected to differences in local cultures, such as views of the preschool teacher’s role in the science activities and the epistemology within the community. As the study was small in scale, patterns at a more general level were difficult to discern.

In this present study, data from the three preschools included in the previous study (Sundberg et al., 2016) are revisited and merged with data from 11 more preschools in order to answer the following research question:

How does preschool culture interact with teachers’ shaping of science activities?

The answer will hopefully provide a foundation for a more generalised picture of how cultural factors interact with the shaping of science activities in preschools.

The Swedish context

In Sweden, early childhood education is provided for children between the ages of 1 and 5 years. In 2016, 83% of the children in these ages were enrolled in a preschool. Science, in terms of giving children opportunities to experience nature, seasonal changes and different life forms, has been an important part of Swedish early childhood education since the end of the nineteenth century (Tellgren, 2008). In 2010, the preschool curriculum was revised to include a more articulated science teaching mission. According to the curriculum, the preschool should strive to ensure that children develop their interest in, and understanding of, the different cycles of nature, how people, nature and society influence each other, science and relationships in nature and a general knowledge of plants, animals, chemical processes and physical phenomena (National Agency for Education, 2011). Also, children should be encouraged to distinguish, explore, document, ask questions and talk about science. However, the revised and more articulated teaching mission are still characterised by the integration of care, upbringing, play and a holistic view of learning – also referred to as educare (National Agency for Education, 2011). The educare culture is primarily aimed at developing children’s confidence in their own learning.
Theoretical framework

Communities of practice, educational cultures and Activity Theory

The concept community of practice has previously been described by Wenger (1998) as a group of individuals who create a shared identity by engaging in and contributing to a specific practice. According to Wenger, the structure of a community is mainly defined by three interacting factors: the extent of mutual commitment, a joint understanding of the mission and a shared repertoire of tools (Wenger, 1998, pp. 72–73). A prerequisite for a strong community of practice is that the members meet regularly to negotiate the meaning and objectives of the community’s practice and develop tools to achieve the objectives. This creates a ‘social glue’ that is based on mutual learning, a sense of belonging and a joint understanding of the purpose of the practice, which in turn creates a clear mission for the members (Wenger, 1998). One example of such a ‘social glue’ is the community’s overarching views of how children learn, what counts as good or desirable learning and the role of the preschool teacher in children’s learning, i.e. the educational culture of each community. Educational cultures have been described by Biesta (2011) as different to learning cultures, where people learn but where the learning object is not always articulated. Learning thus ‘gives a general suggestion for improvement, while education implies that those involved learn something defined, for a particular reason and from someone’ (Biesta, 2011, p. 207). In educational cultures, learning activities aim at specific learning goals and are framed by specific purposes. Thus, the interaction between different preschool communities’ educational cultures and the shaping of science education opportunities can be described by exploring teachers’ valued purposes and judgements about science and the learning activities that the children are provided with.

In this study, Activity Theory (AT) is used as a theoretical framework to describe and analyse how activities in the preschools – the activity systems – are shaped by their cultural settings (Bakhurst, 2009). The theory is based on a sociocultural perspective, where practices are viewed as situated in historical and cultural contexts that give them structure and meaning (Engeström, 1987; Lave & Wenger, 1991). Thus, different types of culturally and historically formed languages, tools, documents, perceptions, symbols, roles and rules implicitly or explicitly shape every practice. The present study draws on Engeström’s (1987) studies of transformation in work and organisations, in which a triangle model is used to describe six interacting elements of an activity or activity system; the object, subject, tools, rules, community and division of labour (Figures 1–3).

The element object is central in AT. According to Kaptelinin (2005) and Bakhurst (2009), the object of the activity is what gives it meaning and describes the intention that the activity is meant to fulfil. In our case, the object is defined as the planned science activities, both in terms of how it is meant to be shaped and what it is supposed to afford the children. The subject, ‘through whose eyes and interpretations the activity was constructed’ (Engeström & Miettinen, 1999, p. 10), can be one person or several people who are involved in shaping the activity by using both physical and mental tools. In this project, we focus on the teachers’ actions and define them as subjects, since our main interest is to explore how they interact with existing preschool cultures when framing and shaping actions and objectives for planned science activities. In our interpretation, the elements at the base of the triangle – rules, community and division of labour – cover how the collaboration is regulated within the community of practice.
Here, the element *community* is outlined in terms of teachers’ overarching views of how children learn, what counts as good or desirable learning and the role of the preschool teacher for children’s learning, i.e. the *educational culture* of each community (cf.

**Figure 1.** Preschool F. Learning about sounds and hearing.

**Figure 2.** Preschool B. Learning about air and space.
The outcome is the result of the interactions between the six elements in the activity system. In activity systems there are often tensions between the different elements. As these tensions disrupt the activity, they can lead to change and development of the (whole) activity system (Engeström, 1987).

**Material and methods**

**Sample**

The data was collected between October 2011 and June 2014 in fourteen preschools. Thirteen of these preschools were situated in different suburban areas in two middle-sized towns in Sweden, and one was located in a countryside setting. All the preschools were within walking distance of recreational areas with footpaths, forests or shrubs, rocks and grass. They all had their own fenced-in outdoor playgrounds and were situated in buildings with rooms designed for specific activities, such as construction work, role play, painting, free play and eating. Thirteen of the preschools catered for children aged 3–6 years and one for children aged 1–2 years. Three of the preschools volunteered to join the project in response to an open question after a lecture about science for in-service teachers. The remaining eleven preschools replied to a specific request to join the project based on their responses to a questionnaire in which they described science activities as a common feature of their practice.

The majority of the staff participating in the study were preschool teachers with a university degree. A minority were childminders, with upper-secondary school level qualifications. Both the preschool teachers and the childminders took part in the educational activities. For the purpose of this paper, the different categories of preschool staff are from now on referred to as teachers.

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**Figure 3.** Preschool T. Exploring the lives of trees. Filled arrows represent tensions found within the activity system.
Data collection

At each preschool the project was initiated in a meeting at which the researchers informed the teachers about the project, but also allowed them to reflect on the science activities in their practice and share their ideas about what science in preschool could be like. These meetings were either recorded (MP3 or video) or field notes were taken. The preschools were then visited on four to ten occasions (97 in total) in order to observe the daily activities and planned science activities. Field notes were taken on all these occasions and the science activities were video recorded. The video recorded activities amounted to 5–12 video sequences for each preschool. The activities were followed up in a recorded (MP3 or video) stimulated recall discussion with the participating teachers, who were asked to comment and reflect on the video sequences or pictures of the activities they had taken part in. The teachers were especially encouraged to discuss the outcome of the activities in relation to what had been planned. Individual semi-structured interviews were then conducted with the teachers with a focus on their views of the preschool mission, science, science teaching in a preschool context and their role in such activities. The interview guide is described in (Due, Tellgren, Areljung, Ottander, & Sundberg, in press).

Ethical principles relating to basic individual protection requirements were followed throughout the project with regard to information, informed consent, confidentiality and the use of data (Hermerén, 2011). These requirements were outlined orally and in writing by informing the preschool staff, children and guardians about the purpose of the study and their rights to refrain from participation. The names of the preschools and teachers have been changed to protect their identities.

Analysis

Engeström’s model of an activity system was used as an analytical tool (Engeström, 1987) to investigate how the preschool culture interact with teachers’ shaping of science activities. The analytical process took the form of a four-step procedure that aimed to describe and compare how science learning affordances are shaped in communities of practices with various educational cultures.

Describing the elements of each particular activity

First, the elements of each particular activity were described. Recorded sequences, pictures and field notes were used to describe the various roles the children and preschool teachers had adopted during the activity, which actions and tools were used by the teachers and what the main focus of the activity was, thus informing subjects, objects, division of labour, tools and outcome. Attention was also paid to whether particular rules or value judgements about science learning were transmitted by the teachers’ actions or communications. In the recorded group discussions and individual interviews, the teachers’ expressed their views about the children’s learning, the role of the preschool teacher, implicit rules, divisions of labour and the structure of each preschool community in terms of its educational practices and ideas about what science activities in preschools should be like. Comparisons between the data from the individual interviews and group discussions in each preschool yielded information about the structure of the community.
Identifying relationships between elements during particular activities

In the second step, each activity was examined as a whole in order to discern any possible tensions within and between the elements. This was because tensions were seen as important driving forces for the outcome (Engeström, 1987). For example, a tension between the elements *rules* and *object* was registered if the local rules stated that ‘all activities must follow the children’s interest’, whilst the science activity had a pre-set (by the teachers) purpose and goal. Also, tensions were explored within the elements *rules*, *community* and *division of labour*. For example, we examined if all the teachers in the community agree on the purposes of the activities, or on how children’s learning could be supported by the teachers’ interactions? If this was not the case, it was noted as a tension within the element community and provided information about the structure of that community: the extent of mutual commitment, joint understanding of the mission and a shared repertoire of tools.

Describing the general relationships between the elements in each particular activity system and in each preschool

Third, the information from steps one and two was merged to construct a general activity system model for each preschool. The process of generating the general features of the elements was guided by questions such as: Are certain kinds of tools preferred in this preschool? Do the objects focus on recurring learning goals? Do some value laden views have more impact on the shaping of the activities than others? Then the relationships, and specifically the recurring tensions, between the elements were noted and set in relation to the outcome.

Comparing outcomes across activity systems

The fourth step focused on the *outcome* across activity systems, guided by questions such as: What is afforded to the children in terms of science learning opportunities at each preschool, and how visible is the planned science learning object during the activity? Do the science learning object and outcome generally align?

The fourteen activity systems (preschools) were then sorted according to how visible the science learning objects were, which in turn resulted in a division of the preschools into two types: I) preschools in which the science learning object was clearly expressed and visible during the activities, and II) preschools in which the science learning objects were largely elusive as they were not actively supported and sometimes overshadowed by other objects (Table 1). This generated a group of nine activity systems of type I and five of type II. The activity systems within each group were then re-examined and compared to determine the similarities and differences in terms of community structure and educational culture.

Results

Varying opportunities for science learning in preschools

In accordance with the previous small-scale study (Sundberg et al., 2016), the children were provided with some kind of science learning opportunities in all the fourteen preschools. Altogether, the preschools embraced a great variety of approaches to science,
such as observing differences, making models, physical and/or sensory experiences, aesthetic methods, factual/conceptual teaching, storytelling, imagination and play, free nature experiences and experiments. In the five preschools classified as type II, the science content of a planned theme or particular activity became elusive in the everyday routines of a preschool practice due to other learning objects being prioritised. In the nine preschools of type I, the teachers’ deliberate framing of the science activities resulted in children being provided with a visible science learning opportunity. The following section describes how the community structure and educational culture interacted with the outcome of the activities. This is followed by descriptions of three of the preschools’ science activities in order to illustrate how community structure, educational culture and outcome can interact in an everyday preschool practice.

### Overview of the relationships between community structure, educational culture and the outcome

Based on data from all fourteen preschools, Table 1 describes the relationships between the community structure, educational culture and science learning opportunities afforded to the children. A general pattern is shown in which preschools with what we define as ‘strong communities’, had a much greater alignment between the object and the

| Community structure | Community educational culture | Science learning opportunities afforded to the children |
|---------------------|------------------------------|--------------------------------------------------------|
| Strong community: strong mutual engagement, joint enterprise and shared repertoire ($N = 11$) | Type I: science learning object clearly expressed ($N = 9$) | Children’s interests initiate the theme. |
|                     |                             | • teachers then plan and lead. |
|                     |                             | • teachers as co-researchers |
|                     |                             | • teachers prioritise the science learning object |
|                     |                             | Example: Preschool F |
|                     | Type II: science learning objects largely elusive ($N = 2$) | Voluntary explorations and sensory experiences of phenomena, where the science content is not articulated during the activities |
|                     |                             | Children’s interests are the highest priority |
|                     |                             | • teachers encourage and challenge |
|                     |                             | • teachers supply material |
|                     |                             | • no ‘rights or wrongs’ |
|                     |                             | • children’s interests allowed to change the planned focus of an activity |
|                     |                             | Example: Preschool B |
| Weak community: weak mutual engagement, with split enterprise and repertoire. Actions renegotiated due to children’s and/or external influence ($N = 3$) | Type II: science learning objects largely elusive ($N = 3$) | Voluntary explorations and sensory experiences of phenomena, where the science content is fragmented and not articulated during the activities |
|                     |                             | Different views of children’s and teachers’ roles during the activities |
|                     |                             | • teachers prioritise ‘doing’ and making products |
|                     |                             | Example: Preschool T |

Table 1. Science learning opportunities afforded to the children in relation to the structure and educational culture of each preschool community. Examples of three preschools representing each category follow in the text. The numbers in brackets refer to the number of preschools categorised in the respective combination of categories.
outcome, compared to ‘weak communities’. Strong communities were characterised by shared fundamental values concerning the teacher’s role in children’s learning and the purpose of a preschool practice. The children were afforded activities that were aligned with the teachers’ intended object. We identified, however, that the strong communities were of both type I and II. In strong communities combined with an educational culture where the teachers prioritised the science learning content, the children were afforded science learning objects that were clearly expressed and visible during the activities. In strong communities combined with an educational culture where teachers prioritised children’s interests, the planned science content became elusive as the teachers chose a passive role in order to make room for the children’s own interests, also when those interests did not involve science. In most cases, these educational cultures were characterised by a strong view of ‘not becoming school’, where teachers equated school and science with authoritative teaching and rote learning. The fear of being a ‘teacher’, in the sense of a school teacher, seemed to result in the children being deliberately left alone to explore, reflect on and talk about the scientific content without the support of an adult to challenge their thoughts. When activities were planned, as a response to the children’s own interests, they were offered as something voluntary, which resulted in only a few children taking part in the activity.

In weak communities, there was a tension within the community in that the teachers did not share views of how children learn, what counts as good or desirable learning and the role of the preschool teacher in children’s learning. This in turn caused both a tension within the object and between object and outcome. The children were typically afforded a vast array of activities aimed at giving them a specific science learning opportunity, but the science content itself was not framed as a joint strategy by the teachers. As the science learning object was not articulated, the children shaped their own object for the activity, which did not always align with the planned science learning content, thereby causing a tension within the object. The result was a science learning object that was fragmented and diffuse, thereby causing a tension between object and outcome.

To sum up, the general conclusion of the results is that in order to afford children with visible science learning opportunities, a strong community has to be combined with an educational culture in which child-centred activities are linked to a teacher-led focus on the science content.

Relations between community structure, educational culture and the visibility of science illustrated by three preschool cases

In the following section, three different preschools – F, T and B – are described to illustrate the categories described in Table 1. The preschools are presented with a short description of the science activities afforded to the children and how the relationships and tensions between and within the elements of the activity system interact in these particular systems to shape an outcome.

Preschool F: learning about sounds and hearing

Preschool F is an example from category I and is a preschool with a strong community and educational culture, where the teacher’s role is to lead, or be a co-researcher, and to be attentive to the children’s questions and ideas. In this preschool, the science learning
goals in the curriculum are interpreted as an important part of the preschool’s mission and something that all children should be afforded. As a result, the science theme is integrated in the ordinary practice and is compulsory. A general rule is that it is important to make plenty of room for the children’s own ideas and investigations, but this should also be balanced with sometimes giving straightforward and factual answers to the children’s questions. The children’s interests and thoughts are carefully attended to by the teachers by taking notes and photos of their questions, activities and explorations. This documentation is later used in the teachers’ weekly meetings to plan the future direction of the science themes and specific activities. In an interview, Carin describes this as:

We plan a week at a time based on the children’s questions. That is what is exciting. You never know where you’ll end up. (Carin, personal interview)

When planning a theme about sounds and hearing, the teachers start out from the children’s own interests by playing and pretending that they are animals. They initiate this by asking the children how animals hear and whether there are differences between animals and human beings in this respect. In the discussion that follows, the children come up with the idea that you might hear better if there is a lot of hair in your ears, as some animals have. The children then test this by putting different kinds of materials into their ears. The hypothesis is then rejected based on the results. In the weeks that follow, the teachers extend the theme by creating a challenging environment and keeping their eyes open for everyday events that could be used as further examples and starting points for new activities. The most common physical tools used are everyday objects and the overall preschool environment.

For example, when a child puts its ear against the table at lunchtime and understands that the sound of the underfloor heating can be heard through the table, the discovery that a sound can travel inside an object is used to initiate discussions and further testing. At lunchtime, the children are encouraged to use utensils to create and compare sounds, which eventually leads to the creation of an orchestra. A ‘sound room’ is constructed with parents’ help – a small room where the walls are covered with instruments and everyday objects that can be used to produce sounds. In all the other rooms there are reminders of the theme, such as small signs asking ‘what sounds can be produced here?’ and photos showing children exploring, producing, transmitting and registering the different kind of sounds on display. The importance of balancing between making room for the children’s own ideas, and sometimes giving straightforward and factual answers is something that the teachers discuss:

For us it is important to listen to the children, see what they do and help them to express what they see, to be an observer and catch up on issues, and not provide too many answers. You have to let them think. (Magdalena, personal interview)

How do you help them with that? (Interviewer)

You can ask questions, such as ‘how does it work?’ to make comparisons. If I give them all the answers they might stop thinking. (Magdalena, personal interview)

Another teacher describes the balancing act between making room for the children’s own ideas and being the one who sometimes gives straightforward answers:
Everyone's thoughts count, but you have to tell it how it is, pure facts, if they ask. (Mary, personal interview)

No tensions within the elements, or between the elements, were found in the activity system of this preschool. The object was to give every child an opportunity to learn about and experiment with hearing and sounds based on their own questions and interests, which aligned with the outcome: during their day at the preschool all the children were afforded a wide range of carefully articulated opportunities to explore sounds and hearing, both guided by teachers and by the children themselves. The analyses of the activities show a preschool in which the children are afforded purposefully framed learning opportunities offering content knowledge, a scientific vocabulary, sensory experiences and discussions of clearly defined phenomena.

The teachers’ weekly meetings, where the children’s questions are discussed, do not only result in new planning for the coming week, but also promote a shared understanding of what to do and how. This interacts with a common understanding and shared view of science as something important that all children should be afforded. A lot of work goes into planning particular activities. When describing their strategies, the teachers emphasise that the most important thing when organising the work is to integrate the science theme into the whole day and also to include other routines. How and what to do during the science activities is further supported by a specific plan for the division of labour. Hence, the elements of the activity system, the subject (the teachers), the tools, the rules, the community and the division of labour all support and frame the intended science learning object and make it an obvious part of the practice.

**Preschool B, learning about air and space**

Preschool B illustrates category II, and is a preschool with a strong mutual engagement and an educational culture in which learning is seen as arising naturally from free play and exploration, not through ‘teaching’:

They should be free to try things themselves and there should be no right and wrong, we want to allow children to explore and test. It shouldn’t be like school, that’s what you think politicians are talking about, they want it to be school. (Janet, personal interview)

In the context of science learning, this means that the preschool teachers mainly wait for the children’s initiatives, provide different kinds of materials and create a joyful, welcoming, and safe environment. They are not expected to shape science education that focuses on one particular learning object and/or a predetermined way of learning. Science themes are still planned, but in comparison with preschool F, less effort is put into the creation of a particular theme and offering a vast array of planned activities connected with it. Science learning opportunities are instead seen as something to be ‘caught in the moment’, when the children show interest in, or explicitly ask questions about, something that is connected to science.

When visiting the preschool, a science theme had been initiated as a result of the children’s interest in ‘Angry Birds’, a video game in which imaginary birds are shot through the air in a sling to destroy the evil pigs’ castles. Originally the idea was to use this interest to inspire the children to explore the properties of air and space in real life. In the recall discussion, Antonia describes the possible learning objects:
It’s about density and gravity. The birds have different weights and [therefore] cause different damage, the birds are supposed to be directed against the boulders and the little birds do little damage to the towers, whereas the heavier birds overturn it. (Antonia, recall discussion)

Some experiments were therefore planned to examine air properties together with the children. However, the science learning object was soon abandoned:

At the beginning it was interesting [for the children] but then they lost interest. We reflected on this and realised that this idea did not come from the children but came from us. So we abandoned it. (Antonia, recall discussion)

The teachers continued the theme because the children still showed interest in the story of the ‘Angry Birds’, although the idea of integrating it with science activities was not further supported. In all the filmed sequences the teachers were either in the background or active by encouraging imagination, play and cooperation. The teachers’ communications were mainly about how the children should behave (take turns, cooperate) or questions about the children’s opinions, feelings and thoughts.

In the activity system described for preschool B, there are no tensions in the triangle. The community has a strong and joint understanding of the purpose of the practice, which in turn creates a clear mission for its members. The outcome is in alliance with the object, as well as with the tools, rules, educational culture and division of labour, as there is no expressed wish to specifically ‘teach’ the children science. However, from a science learning perspective, the children are not given a visible science content to explore. Even though the teachers have clear ideas and the competence to lead activities with science learning objects, such activities are abandoned when they do not align with the educational culture of the community.

Preschool T – exploring the lives of trees
Preschool T illustrates category II where there is a joint understanding of the overall responsibility of the practice, which is to provide a safe and child-centred environment and to inspire the children to cooperate and share experiences with each other. Specific lead words for the practice are cooperative learning, ‘you borrow knowledge from each other, to make something new’, and participation, ‘every child’s right to be an active part of the practice’. Within the community there is also a common desire to provide the children with science learning opportunities, however, with different views of how. Here, the main object is to introduce the children to science as a creative and fun activity, to encourage a lifelong curiosity about the world and to prepare them for school by teaching them some facts. However, as all the teachers are not equally involved in this specific task, the community is split. The science activities are largely initiated and planned by one teacher, Angelica, who is the driving force for most of the science themes and has a keen personal interest in science.

I want to introduce our children to science. So that they continue to ask questions and stay curious. I saw a documentary about Lennart Nilsson, the photographer, who got a microscope when he was little, and how this introduced him to a lifelong affection for scientific questions. That’s what I would like to give our children. (Angelica, group interview)

Most of these activities are implemented by other teachers who do not share Angelica’s keen interest and confidence in science teaching and who also have different views of
the teacher’s role during activities with learning objects. The teachers are very enthusiastic when initiating the activities, but the lack of a joint enterprise and confusion about how to afford all children with the learning object, and at the same time give them a leading position in the shaping process of the activities, result in a lack of any clear idea about the main purpose of the activities.

When the research project started, the ongoing theme of preschool T was to explore the lives of trees. The starting point for the theme was a book that introduced a letter accompanied by pictures and rhymes about trees. Parts of the book were read aloud at morning assembly and some of the children were very intrigued by it, thus inspiring the teachers to initiate a theme that integrated learning the alphabet with learning about trees. A park with exotic species of trees and a Swedish spruce forest were visited. In these two places the children were encouraged to touch and examine the trees and sketch the surfaces of the different tree trunks. Objects like chestnuts, sycamore keys and acorns were collected. In the school playground insects were shaken out of trees and bushes to investigate ‘the secret lives of trees’. When connecting to the alphabet, the children were encouraged to look for sticks shaped like letters, or to arrange sticks on the ground to form letters.

In the morning assemblies the teachers talked about how trees grow, why they lose their leaves in the autumn, and conducted experiments showing how trees transport water up to the leaves. A corner of the preschool was set aside for the science theme and devices such as scales, magnifying glasses and a microscope were provided on a table, always in combination with pencils, crayons and paper so that the children could draw pictures of their findings. Trees were made out of clay or scraps of paper. Books about trees, plants and seeds were borrowed from the library and displayed for the children and the seeds that had been collected during the outings or discovered when eating fruit were sown.

Accordingly, the children at preschool T were afforded a wide range of activities that were purposefully connected to the ongoing theme. However, when analysing the activities, it became apparent that the objective, which was to give the children opportunities to learn about trees, did not align with the outcome. The observed activities were characterised by an enthusiasm on the part of both teachers and children, but often the teachers did not guide the children towards the intended learning object. For example, when making trees in clay, the conversation between the teachers and the children and between the children themselves did not revolve around what trees looked like or any other aspect of trees. Rather, they were about how to manage the clay and various everyday subjects. When they were in the forest, the teachers introduced the children to the purpose of the excursion, which was to experience a typical Swedish spruce forest, but when the children did not seem to be interested in this it turned into free play and the science focus was abandoned. In addition, the fact that science activities were voluntary resulted in only a handful of the children being actively involved.

When we analysed the activity system a number of interacting tensions were revealed. First, we identified a tension between the planned object and the outcome, in that the two did not align. There was a tension between the rules of the community and the object, as the teachers struggled to keep a focus on the planned science learning content (the object) and give the children a leading position in the shaping and processing of science learning (the rule). Victoria and Angelica describe this as follows:
He said that the ice we brought indoors melted, but outdoors it did not. I asked him if he wanted to do a new experiment, but he said ‘It’s not necessary, I know it now’. Where do I go from there? Does it end there, or can I go on with this somehow? (Victoria, introductory discussion)

I have tried to inspire them to think and talk about what the stem of a tree looks like (...) But it is very difficult. The children start thinking about something else. (Angelica, introductory discussion)

Further, the rule to always wait and follow the children’s initiatives caused tension between the tools and the object. The teachers remained in the background, waiting for the children’s questions and comments. As the children often chose to focus on something other than the scientific content, the teachers’ verbal tools, encouraging comments and questions also directed the focus away from the intended science learning object.

A tension within the community that was linked to the other tensions was that all the teachers did not have the same views about children’s learning and did not feel equally confident about teaching science. Their different views of children’s learning were not outwardly expressed but emerged during the individual interviews. For example, in a personal interview Melissa first explains that:

It is the children who are the driving force, but we challenge them to go further. Their thoughts and views are our starting point. (Melissa, personal interview)

In another context Melissa expresses frustration with the philosophy of always following the children’s interests and that there is no right or wrong answer. When working with clay, she wants to help the children by showing them some techniques:

But they [colleagues] told me: ‘you should definitely not show them how to do!’ I would like to show them, to share my experience, so that they can do it in their own way. But they are supposed to do it their own way. And my role is to document, sit beside with pencil and paper. (Melissa, personal interview)

To conclude, preschool T is an example of a preschool with an expressed desire to provide the children with science learning activities. Many science activities are planned, but the lack of any joint commitment and an educational culture that actively frames the science content means that the science learning object is abandoned in the complex everyday preschool practice and gives way to other competing objects, such as play, the children’s own imaginations or more traditional preschool learning objects, such as social and motor skills or the production of different kinds of artefacts.

**Discussion**

Our results show that the structure of, and epistemological beliefs within, a community play a major role for how and whether science is afforded the children. Thus, the results confirm that cultural and historical factors interact with the shaping of science activities, as previously suggested (Sundberg et al., 2016). Our results also show that in order for children to be afforded with clear science learning opportunities in preschool, the community needs to be strong and include an educational culture that allows teachers to lead and intentionally frame the science content.
To be or not to be an educational culture

Preschools in Sweden have long been characterised by the integration of care, upbringing, play and a holistic view of learning – also referred to as educare (National Agency for Education, 2011). This pronounced feature of Swedish preschool culture is primarily aimed at developing children’s confidence in their own learning. Nevertheless, the revised preschool curriculum also states an articulated science teaching responsibility, which indicates a transition from a learning culture, i.e. a culture where people learn but the object is not always articulated (Biesta, 2011), towards an educational culture that also includes teaching science skills and knowledge. The stories of preschool T and B give examples of tensions that can arise in such a transition. It could be argued that no tensions were found in these preschools because there was a consensus within the community that science learning was voluntary, on the children’s own terms and that was what the children were afforded. However, as the Swedish preschool curriculum clearly states that all children should be given science learning opportunities, it can also be argued that in these cases there was a tension between the community and the Swedish preschool curriculum. In these preschools (T and B), the teachers’ concern about ‘becoming like school’, is manifested in the abandoning of planned science activities or compulsory attendance, as this is seen as something negative that will restrict children’s freedom and creativity. The outcome is practical and embodied science activities that give the children a possibility to learn about science, but without active teacher guidance. Gustavsson, Jonsson, Ljung-Djärf, and Thulin (2016) show similar results in their study of teacher–child communication about science content in preschool, hence that the intended science learning object is obscured as an effect of teachers’ will to be responsive to every child’s comments, or to address fantasy and play in their communication about science content. In line with Gustavsson et al. (2016), we argue that it may be difficult for children to learn about science, if the science learning object is not made visible by teachers. Regardless of the teachers’ reasons for holding back on guidance, the children are left to make connections between specific science content and the activities they are taking part in by themselves.

Teachers’ reluctance to plan and lead science activities has been described in previous research. For example, preschool teachers may see it as their primary role to create an environment that encourages children’s own investigations (Fleer, 2009). Further, research has shown that student preschool teachers believe that children ‘discover’ scientific knowledge and skills in ‘teaching free zones’ (Sundberg & Ottander, 2014). At the same time, studies advocate that teacher guidance is a cornerstone for children’s science learning experiences (Nayfeld, Brenneman, & Gelman, 2011; Peterson & French, 2008). In terms of obstacles and opportunities for science in the preschool, our results indicate that the teachers’ fear of fully transforming from a learning culture to an educational culture is a major obstacle to providing children with science learning opportunities in the preschool.

In contrast, preschools such as preschool F (type I) illustrates how teacher guidance can provide children with science learning opportunities without restricting their freedom and creativity. Instead of worrying about ‘becoming school’, the teachers in these preschools are confident about providing science activities that both include science processes and scientific facts, and emanate from children’s interests and ideas.
Implications

Drawing on our findings, we recognise that in-service teachers and student teachers would benefit from tools that help them to explore their own preschool communities. Our study exemplifies how Activity Theory can be combined with the three interrelated dimensions of communities of practices described by Wenger: mutual engagement, joint enterprise and shared repertoire (Wenger, 1998, pp. 72–73). Together these theories can be used to describe how and to what extent a community shares norms, values, objectives and tools, and how those interact with teachers’ shaping of activities with science content.

Previous analysis of interviews with the same teachers as those included in the current study, show that teachers explicitly and implicitly link science teaching with stereotype ideas of school teaching, and perceive school science teaching as authoritative transmission of facts (Due et al., in press). We propose that, if teachers perceive a strong link between science teaching and school teaching, their scope of possible ways of teaching is narrowed as an effect of their boundary work to ‘not become school’. Hence, we would like to initiate a discussion about how pre-service and in-service preschool teacher education can support teachers to challenge their views of school science teaching and preschool teaching, in order to move beyond restricting norms and stereotypes, towards a productive, multi-faceted, preschool science teaching.

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