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REVIEW



Teachers' conceptualisations of science teaching – obstacles and opportunities for pedagogical continuity across early childhood school forms

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ABSTRACT

This study aims to contribute knowledge about obstacles and opportunities for pedagogical continuity in science across early childhood education. We use activity theory to analyse individual interviews and group meetings with teachers from preschool (age 1–5), preschool class (age 6) and grade 1–3 (age 7–9) in three Swedish school units. The teachers' descriptions of their science teaching indicate both obstacles and opportunities for pedagogical continuity. For example, all teachers want to establish an interest in, and foster a caring attitude to nature, a similarity that facilitates continuity. However, some crucial differences indicate obstacles. There is a shift concerning ownership; from following children's initiatives in preschool in bodily and play based experiences towards an emphasis on pre-planned content, verbal knowledge and written documentation in grade 1–3. Our findings also suggest that teachers lack knowledge about each other's teaching and curricula. Hence, the conditions for pedagogical continuity largely rest upon what children share in the science class. We argue that there is need for an in-depth exchange of experiences, regarding content, teaching methods and frame factors, between teachers from different school forms.

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Introduction

Recent studies concerning early childhood science education show that children can be afforded rich science learning experiences in preschool (Areljung and Sundberg 2018; Fleer 2019). However, little is known about whether and how primary school teachers build on and extend children's previous experiences in science. Studies regarding other school subjects indicate that much of the knowledge and experiences children gain in preschool are not considered in school (Skoog 2012; Ackesjö 2014), and this lack of continuity may, according to Dewey (1938/1997) have a serious impact on children's learning possibilities.

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In this study, our aim is to contribute knowledge about pedagogical continuity in science across EC school forms in Sweden. We start by analysing similarities and differences between teachers' descriptions of their own science teaching, in order to identify obstacles and opportunities for pedagogical continuity. In doing so, we use activity theory (Engeström 1987) to analyse individual interviews and group meetings with teachers in preschool (children age 1–5), preschool class (age 6) and grade 1–3 (age 7–9) in primary school.

Three different ECE school forms – the Swedish context

In Sweden, early childhood education (ECE) is organised in preschool and compulsory school. *Preschool* (age 1–5) is voluntary, but as many as 83 percent of all children are enrolled. Compulsory school consists of preschool class (age 6) and primary school (age 7–16), which includes grade 1–3, grade 4–6 and grade 7–9. *Preschool class* is a separate school form which aims to enable a smooth transition between preschool and school, by offering playful meetings with school requirements.

Historically, preschool and school reflect different educational cultures and goals (Huser, Dockett, and Perry 2016). In Sweden, the educational culture of preschool builds on a holistic approach in which care, development and learning are seen as intertwined, and are based on children's interests, curiosity, and play (Sandberg et al. 2017). The educational culture of the school is more subject-oriented and goal-driven (Pramling Samuelsson and Asplund Carlsson 2008). The main task of the preschool class is to intertwine these divergent educational cultures (SOU 1997:21).

The preschool curriculum (Swedish National Agency for Education 2018) does not state any individual goals to achieve for each child, but there are goals for the activities. Preschool class and primary school are both covered by the curriculum for the compulsory school, in which preschool class has its own section (Swedish National Agency for Education 2019). Subject specific knowledge requirements exist for each child, which should be achieved by the end of grade 3.

Common to all three school forms is that children's experiences, interests, and prior knowledge should guide the science teaching. The children should be supported to develop their ability to explore, describe with different forms of expression, ask questions, and discuss science. In preschool, a caring attitude to nature is emphasised, as well as relationships in nature, knowledge of plants, animals and simple chemical processes and physical phenomena (Swedish National Agency for Education 2018). This content is also found in the curriculum for preschool class and primary school, but it becomes more extensive and detailed, and the explorations are expected to become more systematic. In primary school, critical thinking is added, as well as an understanding that statements can be evaluated by using scientific methods.

There are also differences according to organisational conditions, such as group sizes, regulation of time and space and the degree of voluntariness in participation.

Continuity between school forms

Previous research shows that the transition from preschool to compulsory school can be crucial to a child's further education (Huser, Dockett, and Perry 2016; Ackesjö 2014;

Skoog 2012). Transitions involve physical and social changes, but also a movement between different educational cultures (Ackesjö 2014). A central concept relevant to transition processes is *continuity*. According to Ackesjö's (2014) continuity refers to the way a school form relates to and builds on another school form, for the benefit of the children.

Our study focuses on pedagogical continuity, a concept based on Dewey's (1938/1997) principles of continuity (see Theoretical considerations). In this concept we partly include communicative, curricular, organisational, and cultural continuity. These are different forms of continuity that have been identified as important to facilitate children's transitions (Ackesjö 2014). Communicative continuity refers to exchange of information between teachers in different school forms; curricular continuity refers to knowledge about each other's curricula; organisational continuity concerns how education is organised in different school forms. Finally, cultural continuity refers to aspects underlying the teaching, such as views of children, teaching, and learning (Ackesjö 2014). In practice, all these aspects interact and may affect children's transitions.

Similarities and recognition between different school forms is often put forward as desirable and a key factor to facilitate continuity and children's transition processes (Dockett and Perry 2007; Ackesjö 2014). At the same time, similarities in terms of 'more of the same' can be an obstacle for learning. Ackesjö (2014) also shows that differences, often regarded as problematic discontinuity, can be experienced as something positive and inspiring by the children. The encounter with something new can mean increased self-reflection and growth, involving reconstruction of identities and roles in the new context.

EC teachers' conceptualisations of early science teaching

One of our points of departure is that teachers' conceptualisations, in terms of how they describe the nature of science and their science teaching, both mirror and have consequences for practice, and accordingly for the opportunities for continuity in science education.

Most international research, based on surveys and interviews of EC teachers and student teachers, pay attention to teachers' negative attitude and an expressed lack of self-confidence and knowledge when it comes to teaching science compared to other subjects (Appleton 2002; Murphy, Neil, and Beggs 2007; Spektor-Levy, Keisner Baruch, and Mevarech 2011). Attitudes towards science are thus well researched, while studies concerning EC school teachers' descriptions of their own science teaching, which is the focus of our study, are rare. Further, there are no studies that compare teachers' conceptualisations of science teaching across EC school forms.

Due to the different educational cultures in a Swedish context (Sandberg et al. 2017; Pramling Samuelsson and Asplund Carlsson 2008), there are reasons to believe that teachers in preschool and school conceptualise science teaching in different ways. In a study that investigates how preschool teachers describe their own science teaching, the teachers contrasted their pedagogy with the teaching in compulsory school (Due et al. 2018). They emphasised that children's ideas and initiatives were more frequently used in preschool and regarded themselves as co-researchers when investigating science issues. They pointed out that the activities were voluntary and arranged in time and space in a different manner. One of their main aims was to offer the children to feel and explore

scientific phenomena with their own bodies. This was also noticed by Hellberg, Thulin, and Redfors (2019) and by Gustavsson and Thulin (2017) in a questionnaire concerning preschool teachers' perceptions of science teaching, before and after a science development project. Gustavsson and Thulin (2017) also noted that the teachers initially were quite vague when expressing the science content. Science was mostly about nature and values such as care and sustainability. The doing was in focus – singing, playing, and creating. Only a few teachers initially talked about science as a process-oriented approach. This was also discussed by Eshach (2006), who states that science is not only domain specific conceptual knowledge, but also a more general procedural knowledge that concerns *how* to gain knowledge in science.

In Sweden, studies concerning primary school teachers' talk about science education for younger children are rare. However, international research shows that school teachers' (grade 1–3) also highlight practical activities and want children to enjoy science lessons. In his study, Appleton (2002) shows that Australian primary school teachers preferred hands-on activities, designed to arouse the children's interests and curiosity. Lunn (2000) shows that primary teachers in the UK highlighted scientific inquiry as an important part of teaching science. Further, they wanted their students to enjoy science lessons and to connect science to everyday experiences. However, the teachers talked about pre planned science activities, not about following children's initiatives.

Aims and research questions

Given the limited research on pedagogical continuity between EC school forms in the subject of science, the aim of this article is to contribute knowledge about conditions for pedagogical continuity in science across EC school forms. Starting by analysing similarities and differences in teachers' descriptions of their own science teaching we seek to respond to the following research questions:

- How do teachers conceptualise science teaching in their own EC school form?
- What obstacles and opportunities for pedagogical continuity across EC school forms emerge through teachers' conceptualisations of their science teaching?

Theoretical considerations

The theoretical points of departure draw on Dewey's principles of continuity of experience (Dewey 1916/1944, 1938/1997) and Engeström's Activity Theory (Engeström 1987, 2001). These two theoretical frameworks are both consistent with a view of teaching and learning as socially situated activities.

Pedagogical continuity

A central concept, relevant for smooth transitions between school forms, is *pedagogical continuity*, based on Dewey's (1916/1944, 1938/1997) theories of children's meaning-making. Dewey points out that every new experience relates to previous experiences, and in turn modifies future experiences. We use old experiences to make sense of new

ones and the gap cannot be too big or too hard to bridge, otherwise the continuity of learning opportunities will be broken. Recognition is then important for continuity and similarities between children's past and present experiences support recognition. But the word *pedagogical* in the concept pedagogical continuity also asks for something new to be learned, that the children are offered opportunities of new insights. According to this, the challenge for teachers is to offer children experiences, which are both connected to previous ones, and renew and deepen their knowledge. If the meaning-making that occurs in this transaction also forms the basis for new experiences, smooth transitions might be facilitated.

Activity theory as a lens on teachers' descriptions

In order to analyse the teachers' descriptions of science teaching, and to be able to compare different aspects of teaching between school forms, we use Activity theory (Engeström 1987, 2001). Activity theory is based on a Vygotskian perspective of how the cultural historical context both forms and is formed by the activities that take place. Different types of culturally and historically formed languages, tools, documents, perceptions, symbols, roles and rules implicitly or explicitly shape every practice, every activity system. Activity theory offers a structure, which captures the teaching as a situated activity, where different aspects of teaching, nodes, that interact and shape the teaching, become visible (See *Analytical process* for further details). By exploring these nodes in relation to each other, one can sometimes identify tensions and thus get a clue as to whether there are factors that limit the activity. Tensions can for example bring with them that the teachers' intentions with the activity, cannot be realised. Together, the nodes and possible tensions form a broad picture of the activity, in our case the science teaching described by teachers in different school forms.

We draw on the third generation of Activity Theory, developed by Engeström (2001), which emphasises that activity systems are constantly interacting within a network of other activity systems. This is another level that is important to include in our analysis. Children's transitions between different school forms can be understood as moving from one activity system to another and activity theory may serve as a tool for comparing these activity systems. When different organisations are struggling for a common object (for example opportunities for children's science learning) an analysis that includes and compares all aspects of their activities can give a clue to whether they will succeed or not. The focus is then on identifying tensions between systems to understand how change and development could be achieved. In our study, we start by analysing similarities and differences between teachers' descriptions of their own science teaching in different EC school forms, in order to identify obstacles and opportunities for pedagogical continuity.

Method

Research design, sample, and data

The study presented in this article is part of a larger research project, concerning obstacles and opportunities for pedagogical continuity across school forms in early

childhood science education. Data was collected in three public Swedish school units (A, B, C), comprising four preschools, four preschool classes and four grade 1–3 classes. In total, 21 teachers participated. All but one, were graduated teachers. For a majority of the school teachers, science was included in their teacher education. The preschool teachers' and preschool class teachers' level of science education varied from upper secondary school to university level.

The design of the larger study was a cyclical intervention process, with individual interviews, group meetings and classroom observations. In this study, we focus on a subsample of the data consisting of the *initial* interviews, in total 21, and the *first* group meeting within each school unit, in total three. This choice is based on our interest in the teachers starting position regarding their own science teaching, i.e. before the research interventions started. All researchers in the project participated in the data collection. The interview questions were guided by the questions connected to the nodes in the activity triangle (Figure 1) and concerned the teachers' experiences of and thoughts on science and science teaching. The discussions at the group meetings focused on similarities and differences regarding curricula and science teaching in the different school forms. All interviews and group meetings were audio- or video recorded and transcribed verbatim, in total 30 h of recordings.

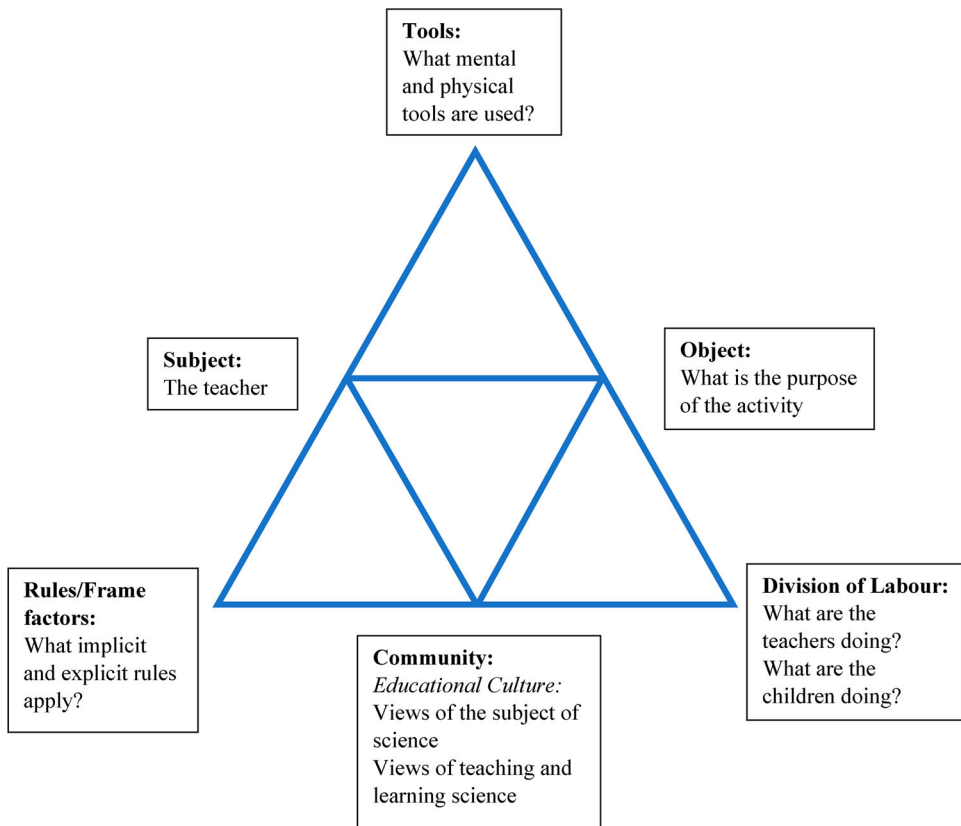


Figure 1. Triangle model showing interdependent nodes, inspired by Engeström's (1987) model of activity systems.

Ethics

The study has followed the ethical principles outlined by the Swedish Research Council (2017), regarding informed consent, right to withdraw from participation and use of data. All participants are anonymised to protect their identities.

Analytical process

The central tool in our analysis is the activity triangle with its nodes, concerning different aspects of the activity of an organisation, in our case the science teaching in different school forms (Figure 1). The node *object* in the triangle is the teachers' intentions with the activity. The other nodes in the model are the *subject*, i.e. the teachers that initiate and lead the activity, the *tools* used, both material and cognitive, the *rules*, both formal and nonformal, the *division of labour*, i.e. who is doing what, and finally, the *community*. The community is, according to Engeström (1987), all the people involved in the activity. However, in our analysis, we choose to understand the node community as the prevailing educational culture, in terms of teachers' views of science, teaching and children's learning.

Two of the researchers were responsible for the analytical process and started by reading the transcripts several times. In the first step, the initial coding, we searched for utterances that responded to the different nodes in the activity triangle. We constructed three triangle models, one for each school form, hence including teacher's descriptions from all preschools in one triangle, all preschool classes in one and all school classes in one. In a second step, both researchers separately analysed the content of the teachers' descriptions for each node and then compared their interpretations. This resulted in a generalisation based on utterances common to the teachers within each specific school form. As an example, the generalisation 'Start from children's interests' connected to the node Community in the triangle for preschool, was based on utterances like: 'What do they want to do? Then we do it in preschool' (P2/B); 'There will be different focus areas based on what the children are interested in.' (P1/C). We also took notice of utterances that opposed what the majority argued, and these were noticed in the analysis as a sign of possible tensions *within* the nodes. Tensions *between* the nodes were also noticed. An example is the identified tension between the nodes Rules and Community that appears when frame factors counteract the teachers desire to let the children's interests guide the teaching in preschool class.

The three triangle models gave a multifaceted picture of how teachers in different school forms conceptualised their science teaching. In the third step, to ensure trustworthiness, all researchers were involved in comparing the triangles, looking for similarities and differences, in order to understand what conditions that could have an impact on the obstacles and opportunities for pedagogical continuity between the school forms. In the result section, we mainly describe similarities that may promote pedagogical continuity and differences that may imply obstacles to continuity. In the discussion section, however, we suggest that differences between school forms under certain circumstances may benefit children's learning, and that similarities between school forms can in some cases mean an obstacle to pedagogical continuity and development.

Results

When analysing teachers' conceptualisations of their science teaching, looking for similarities and differences between school forms, in order to identify obstacles and opportunities for pedagogical continuity, it becomes obvious that the similarities prevail. However, there are also some crucial differences. In [Tables 1](#) and [2](#), we summarise these similarities and differences between the school forms, related to the different nodes in the activity triangle. Our results indicate that preschool class holds a special position. [Table 1](#) illustrates that there are similarities between preschool class and preschool at some points (marked grey), which differ from descriptions made by the school teachers. [Table 2](#) shows similarities between preschool class and school (marked grey), which differ from the descriptions made by preschool teachers.

Below, we present the results in relation to our two research questions. Each subheading is a synthesis of several, closely related, generalisations of the teachers' descriptions, shown in the table above. Quotes from the teachers are coded as follows: P = Preschool teacher, C = Preschool class teacher, S = Primary school teacher. 1, 2, 3 etc. refer to different teachers in the respective school form. A, B and C refer to the different school units.

Teachers' conceptualisations of their own science teaching

A personal engagement in nature

All teachers express a personal interest in nature and regard science as accessible in the sense that 'science is everywhere'. However, when they provide examples of science activities they mainly relate to biology, and particularly to 'being in the forest' (C1/A). Several teachers express that they lack knowledge and interest in physics and chemistry, which affects their teaching and require more planning and preparation:

Because you do not have it [chemistry and physics] around you in the same way [as biology].
Sure, we have seesaws, swings, scissors, and all this, but you don't think about it in the same

Table 1. Teachers' conceptualisation of their own science teaching in relation to the nodes subject, object, and community in the activity triangle.

Nodes	Preschool	Preschool-class	Grade 1–3
Subject			
The teachers		Personal interest in nature Primarily comfortable with teaching biology, whereas physics and chemistry are perceived as more difficult	
Object			
The purpose of the teaching		To prepare for the next school form To learn science To enjoy and care for nature	
		Focus on children's experiences of science/natural phenomena	Focus on children's conceptual knowledge in science
Community			
Views on the subject of science.		Practical learning, preferably outdoors. Pleasurable, engaging and involving all senses	
Views on teaching and learning science		Learning science is learning a specific language Play and learning regarded as integrated Start from children's interests	Play and learning regarded as separate activities Arouse children's interests

Table 2. Teachers' conceptualisation of their own science teaching in relation to the nodes division of labour, rules/frame factors and tools in the activity triangle.

Nodes	Preschool	Preschool-class	Grade 1–3
Division of labour			
What are the teachers doing?	Teachers: asks questions, revisits, and reminds, expands knowledge, challenges the children's thinking		
What are the children doing?	Children: listen, ask, and answer questions, explore, draw, write, create, inspire, and help each other		
	Teachers are co-researchers	Teachers are not described as either a co-researcher or an authority	
	Children initiate activities, teachers catch the moment		
		Teachers initiate and lead activities, but is responsive to children's interest	
Rules/frame factors			
What implicit and explicit rules apply?	The curriculum is the basis for teaching		
	Several goals can be reached simultaneously (social, subject-related)		
	Science activities mostly voluntary	Science activities mostly mandatory	
	Flexible plans	Firm plans	
	Curriculum not detailed, no science knowledge requirements	Curriculum more detailed, science knowledge requirements for grade 3	
	Smaller groups, higher staff density	Larger groups, lower staff density	
Tools			
What mental and physical tools are used?	Outdoor environments		
	Materials for creative activities		
	Books and digital resources		
	Dialogues		
	Reminders of past experiences		
	More of songs, games, play and creative activities	More of children's documentation through writing and drawing	

way as you think about the leaves and the wood-louses ... you must think once again to remember physics and chemistry (P1/C).

There is one exception to this attitude towards physics and chemistry. One of the pre-school teachers (P1/A) tells, very enthusiastically, about a project concerning the verb 'fly', which include experiments around physics concepts such as gravity, thermodynamics, and air resistance.

The teachers' commitment in nature is also reflected in how they view the purpose of their science teaching. They want the children to develop an interest in science, but also learn facts. In addition, an ambition is to foster a sense of wonder in the approach to science. The teachers encourage emotions such as empathy and caring for nature by fostering a feeling of being 'a part of the whole thing, but also to feel that you are a guest in some way' (S2/A).

Practical experiences, play and/or verbal knowledge

When describing their views on science teaching, all teachers agree that practical experiences, preferably outdoors, is important for the children's learning. These are seen as pleasurable, engaging, explorative and involving all senses. Both preschool teachers and preschool class teachers point out that one ambition is to offer the children opportunities to 'be close and feel things' (P1/C). The school teachers also stress the importance of practical experiences but tend to be more focused on verbal knowledge and facts, although some teachers are concerned about the children's gradually increasing

anxiety of ‘giving the wrong answer’. In addition to their enthusiasm for practical activities, all the teachers stress that learning science is closely related to learning a specific subject language, and consequently they consider it important to be consistent in their word usage and ‘to use these words over and over again’ (S1/B).

As shown above, the teachers consider ‘doing science’ as important. However, on a meta level, the teachers’ view of science as inquiry is not fully articulated. Although the teachers’ descriptions reveal that they all consider practical activities and experiments as a significant part of teaching science, they do not explicitly talk about systematic inquiry as a part of the concept of science. One exception is a preschool teacher who talks about science, not only as content, but also as a way to gain knowledge about the world through systematic inquiry, for example by designing experiments and making hypotheses.

Practical experiences can also be gained through play, but the role of play is described in different ways by the teachers. The preschool teachers and the preschool class teachers consider play and learning as integrated processes, where play can provide desirable experiences of science phenomena. Although some teachers in preschool class posit that their teaching is ‘more at play level’ (C1/A), their descriptions of the practice suggest that they gradually increase the use of documentation while processing the science content. The school teachers, on the other hand, often describe play and learning as separate activities and focus on verbal communication and writing.

To start from or to arouse children’s interest in science

A significant difference between preschool and preschool class on one hand and primary school on the other, concerns the teachers’ view on children’s initiatives. Both preschool teachers and preschool class teachers emphasise children’s ownership meaning that science teaching should be based on the children’s interests and initiatives. They want to ‘capture the moment’ and pay attention to when the children show curiosity or initiate an activity, because ‘when you work based on their own interests, they become enthusiastic’ (P2/C). The school teachers also stress the importance of children’s interests, but they see it as their mission to arouse the children’s interest in a pre planned science content, rather than picking up on children’s expressed interests. One school teacher says that ‘When you offer new knowledge that they have not encountered before, they become very interested’ (S1/B).

However, the extent to which the planning is fixed or adaptive to children’s initiatives varies between the school forms. In preschool the teachers’ view on how childrens’ interests initiate activities align with how they describe their practice. They pay attention to the children’s preferences and curiosity and act as co-researchers during the activities, following the initiatives of the children.

When you see what they are doing, you must capture their interest at once. At the very moment (P1/C).

The preschool class teachers express a similar view concerning children’s initiatives, but when describing their practice, a tension is revealed. The guidance from the teachers in preschool class is more pronounced, and they stress that they must relate to factors such as curriculum, schedule, and group size. One preschool class teacher says:

I like to be guided by the children to some extent, at the same time looking at the current framework, so that you don’t do something that does not fit. (C1/B).

The preschool class teachers' utterances concerning their roles as leaders in the classroom are thus closer to the ones of the school teachers. In school there is, according to the teachers, even less room for the children's initiatives and the teachers lead the pre-planned activities. They do not talk about themselves as co-researchers though considering the children's questions and suggestions.

Opportunities and obstacles for pedagogical continuity

In this section, we present differences and similarities between the teachers' descriptions that may have an impact on opportunities and obstacles for pedagogical continuity in science.

Teachers' views on science

As shown above, the teachers share the view that science is about nature and almost merely about biology. Physics and chemistry, as well as science as systematic inquiry, are not articulated to the same extent. According to the teachers' descriptions, learning science is also about emotions; to wonder at, learn to care for, feel safe in, and enjoy nature. The consistent view on the content of science education suggests that children encounter similar content in all school forms. This may promote pedagogical continuity, provided that the content is deepened and broadened in the next school form.

To look forward and backward

All teachers, regardless of school form, express that it is important to prepare the children for the next school form. They strive to lay a foundation for future studies, especially when it comes to understanding and using scientific concepts, and they try to 'use all the right concepts and everything, so they [the children] have something in their backpacks when they come to school' (P3/C). The teachers also look backwards when introducing a new science content, asking the children about activities and experiences in previous school forms. One teacher exemplifies how she began a lesson on the life cycle of an apple: 'At first they had to think for themselves, then write down and draw what they thought ... to see what they knew' (S2/B). The teachers' revisits and reminders have a bearing on pedagogical continuity as it makes it easier for children to connect their previous activities and knowledge to new phenomena and experiences. When the children share their previous experiences this also, according to the teachers, provides them with a foundation to build upon and opportunities to challenge the children.

Freedom and ownership or restrictions connected to frame factors

A central difference between the preschool teachers' descriptions on the one hand, and the preschool class teachers and the school teachers' descriptions on the other, is how the children's interest and initiative are treated, and become or do not become part of the teaching. In preschool, the children's interests are the starting point for science teaching, while in preschool class and in school the teachers seek to arouse the children's interests in pre-planned science content and activities. This shift concerning learning ownership is perhaps the most prominent gap and discontinuity in this study.

In parallel with this shift in ownership, there is a change concerning frame factors. The teachers are aware of several differences between the curricula in the different school forms, and their consequences for teaching and learning. Here, preschool teachers' experiences that 'We have no knowledge requirements in preschool' (P2/A), stand in stark contrast to the preschool class teachers' experiences that 'We have to think about grade three all the time. We look at the goals and search for "What do we have in line with third grade?"' (C1/B). One of the primary school teachers says that 'I can sometimes feel jealous of preschool, or not jealous, it is the wrong word, but the fact is that some children do not fit into this form' (S1/A).

The teachers' talk also points at significant differences concerning the child-teacher ratio. In preschool class and school there are larger groups and lower staff density compared to preschool. Further, the children's participation in science activities is often compulsory. In total these frame factors, according to the school teachers, give less space for the children's initiatives and for the teacher to consider the interests of each child. One school teacher says:

At school, it is stressful ... and we have a schedule to follow, maybe it's the sports lesson or they have the music lesson. We are more governed by such things ... organisational framework that governs a lot (S1/C).

In contrast, the preschool teachers refer to their open curriculum, as well as to organisational conditions, when describing their planning as flexible, enabling them to follow children's initiatives.

Discussion and conclusions

This study aims to contribute knowledge about obstacles and opportunities for pedagogical continuity in science across early childhood education. Our findings align with previous research concerning teachers' views on the content and teaching methods of science education. A partly new approach and a strength of this study is our focus on continuity in science teaching, that the study includes three different EC school forms, and that we use activity theory as an analytical tool to provide a broad picture of teachers' descriptions of their own science teaching. Some limitations of the study are worth mentioning. First, the number of participating teachers from each school form is somewhat limited. Thus, generalisations cannot be made based on the sample. Secondly, our results build merely on interviews and group meetings. If we had added classroom observations, this would probably have provided a more comprehensive picture of science teaching in practice. Despite these limitations, we argue that our study, whose credibility is connected to the reader's recognition, and how they can link the results to their own experiences in similar contexts, provides new knowledge and also raises further questions regarding conditions for pedagogical continuity in science EC education.

Important findings

The teachers in our study express similar views on the science content. This is an important finding, which implies good opportunities for pedagogical continuity, *provided* that the children are offered new insights (Dewey 1938/1997). Similarities support

recognition, and recognition is according to Dewey (1938/1997) an important factor for continuity. The teachers' ambition to link science teaching to the children's previous experiences and to prepare the children for future studies also implies pedagogical continuity. Other important findings, which on the other hand indicate obstacles for continuity, are associated with the change in children's ownership, as well as a risk that the children become carriers of continuity in transitions between school forms.

Differences – obstacles for learning or a desirable part of children's growth?

Some of the differences between the school forms, emerging from the teachers' descriptions of science teaching, may create obstacles for learning, and some may not. The most prominent difference is the shift from following children's initiatives in bodily and play-based experiences in preschool towards an emphasis on pre planned content, verbal knowledge, and written documentation in primary school. These differences create a risk for discontinuity, as children seem to move from having much, to having little, personal influence on the inquiries that guide science teaching (cf. Andersson and Gullberg 2014). Children's sense of ownership and interest in science may suffer from this discontinuous transition from preschool to a goal driven school, but the changes in science teaching also offer new opportunities, including a broader general education in science, and learning to use tools such as writing and documentation to understand and communicate science. However, our results illustrate that it is difficult to combine students learning ownership with a goal- and result driven school.

As shown, many of the teachers focus on biology and avoid physics and chemistry (cf. Gustavsson and Thulin 2017). This finding raises questions about pedagogical continuity in relation to the next stage, i.e. after grade three, if physics and chemistry then become more prominent parts of science teaching. However, an extended science content may not necessarily imply discontinuity, if the teaching methods are similar to the ones the children have encountered before. For example, we suggest that teachers can support continuity by building on children's previous experiences and engagement (Dewey 1938/1997), including emotions, caring, joy and wonder as a part of the content (cf. Gustavsson and Thulin 2017). In addition, from the children's perspective, the introduction of a new content can be experienced as an exciting challenge and an opportunity for growth (cf. Dockett and Perry 2007; Ackesjö 2014).

The teachers in our study do not explicitly highlight systematic inquiry, as part of the science content, although it is included in the school curriculum. This can increase the risk of discontinuity in relation to future schooling. The teachers' vaguely articulated view on science, for example a conflation of inquiry as a teaching method and as a specific science content, is also noticed in earlier studies (Eshach 2006; Gyllenpalm and Wickman 2011; Gustavsson and Thulin 2017). This conflation may decrease the children's opportunities to appropriate science as inquiry to explore the world.

The preschool class dilemma

Preschool class is a unique Swedish school form, but the preschool class dilemma is relevant to an international reader as it illustrates a gap between preschool and school

(Huser, Dockett, and Perry 2016). Our results indicate that preschool class teachers culturally identify with the preschool while organisationally belonging to the school. This aligns with previous research (e.g. Ackesjö and Persson 2016) which shows that preschool class teachers are positioned in an area of tension between two educational cultures. The way they want to conduct science teaching, their cultural identity, is closer to that of preschool teachers, but they are subject to several frame factors, which they often share with school teachers (Tables 1 and 2). As an example, the preschool class teachers wish to base their science teaching on children's interest and initiative, and integrate play and learning, but in practice they experience that this is not possible, due to organisational factors.

Pedagogical continuity as a part of the teachers' mission

The teachers emphasise the curriculum as a central tool in teaching, which points to the potential of the curriculum as an instrument that can promote continuity. But for curricular continuity to be realised in practice, it presumes that teachers are familiar with both forthcoming and preceding curricula. Since in practice there is a great variation in science teaching, both within and between the school forms (Areljung and Sundberg 2018; Fleeer 2019), there is also a need for direct exchange of experiences between teachers in the different school forms.

The importance of communication across school forms is also stressed by the fact that a lack of knowledge concerning earlier school forms can bring that the connection to children's previous science experiences largely rests on the children themselves, i.e. what they choose to tell (Author forthcoming). This is quite a fragile construction, which might lead to continuity built on experiences of just a few children (cf. Elm Fristorp 2012). Rather, a more solid opportunity for pedagogical continuity should rest on teachers' own knowledge about previous science education.

A deepened knowledge of each other's science content, teaching methods and the organisational framework that governs the teaching, calls for communication, meetings, and visits across school forms. Such encounters can contribute to increased understanding, inspiration, and knowledge about what the children have experienced and will experience in the future, i.e. promote pedagogical continuity and enable teachers to adapt their teaching. It is thus not just a matter of looking forward, for example preschool teachers adapting their teaching to school, but also for primary school teachers to look backward in terms of paying attention to the preschool pedagogy.

Many of the differences in teaching between the school forms are products of political, cultural, and organisational conditions and may as such be perceived as difficult to change for an individual teacher. However, we argue that teachers' knowledge about each other's activities, educational cultures and frame factors, and how these factors are related to each other, is a key factor for bridging the gaps between the school forms. We conclude that a transition work is needed, in which the tensions are highlighted, concretised, and verbalised.

This transition work must be supported by principals, who acknowledge the importance of arenas for pedagogical discussions across school forms in order to promote pedagogical continuity.

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