Potential for multi-dimensional teaching for 'emergent scientific literacy' in pre-school practice

● Sofie Areljung ● Bodil Sundberg

This paper has also appeared in: Finlayson, O., McLoughlin, E., Erduran, S. & Childs, P. (Eds.) (2018) Electronic Proceedings of the ESERA 2017 Conference. Research, Practice and Collaboration in Science Education. Dublin, Ireland: Dublin City University.

ISBN 978-1-873769-84-3.
Reproduced here with permission from ESERA.

Abstract

How can pre-school teachers form science teaching in a landscape of increasing focus on academically oriented learning outcomes, without losing the unique character of pre-school pedagogies? Seeking to contribute to the discussion of what pre-school science can be, we have analysed data from activities in fourteen Swedish pre-schools (for children aged 1-5 years), to examine if and how multi-dimensional teaching may be combined with teaching for scientific literacy. The overall picture is that elements of 'emergent scientific literacy' can be combined with a wide range of teaching dimensions, such as empathy, fantasy and storytelling. These results contribute important perspectives to what pre-school science can be and how it can be researched in a way that is suitable for the pre-school's conditions. We suggest our analytical questions, and the dimensions displayed in our results, as a tool for teachers who plan or evaluate science teaching in the early years.

Keywords: Early childhood education, science education, schoolification, aesthetics, emergent scientific literacy.

Introduction

- A group of children and a teacher gather around a drain on the side of the street, listening to the echoing sound of drops hitting the water surface deep down.
- Teachers encourage children to touch and taste snow and to listen to the creaking sound of their peers treading on snow-covered ground.
- A teacher helps children to build a nest for a plastic magpie, asking them to think of what the magpie might need to feel comfortable in its nest.

These three snapshots, from a pre-school for children aged 1-2 years, include several dimensions: children's sensory experiences (of water and snow), making (a bird's nest), and caring (for a fictive organism). They also include teacher-child interactions that relate to science content, such as sound, properties of snow and birds' living conditions. Yet, are they examples of science education?

We, the authors, are trained scientists/science educators and have been schooled in the science teaching traditions of compulsory school and higher education. However, in 2012 we began researching how science activities are shaped in Swedish pre-schools. Since then, we have been occupied with questions about what early years science education can be, because we soon realised that our school-oriented science standards were not adequate to describe the activities that we encountered in pre-schools, such as the snapshots above. Our questions adhere to a general 'schoolification' debate, dealing with the increasing focus on academically oriented learning outcomes in prior-to-school institutions and the tendency of compulsory school standards to put a downward pressure on prior-to-school education (Moss, 2008). Researchers have raised concerns that schoolification threatens the characteristics of pre-school pedagogies: for example, the role of care (Gananathan, 2011) and play (Gunnarsdottir, 2014) in pedagogy. When it comes to science education, Klaar and Öhman (2014) recognise the risk that a growing focus on conceptual knowledge may lead to subject-specific teaching at the expense of the subject-integrated, multi-dimensional teaching that often characterises pre-school pedagogies.

How can teachers form science teaching in a landscape where the focus on academically oriented learning outcomes is increasing, without losing the unique character of pre-school pedagogies? Is there room for the type of multi-dimensional teaching displayed in the above snapshots when science education is implemented in pre-school? The answer could be yes, if we consult recent studies of how Swedish pre-school teachers talk about their science teaching. For example, the teachers in Westman & Bergmark's (2014) study indicate that *'a child's whole being, mind and body, are used in the learning process'* (p.78), considering emotion and embodied experiences as prominent parts of scientific exploration. Further, Areljung, Ottander and Due (2016) show that teachers include imagination, individual taste, dramatising, as well as experiments, in their talk of science activities. While these studies mainly build on teachers' talk about their practice, the current article attempts to display examples of multi-dimensional science teaching that are based on observations of practice. Here, we use the term 'multi-dimensional teaching' to refer to a type of teaching that intertwines science content learning with multiple dimensions of children's lives, such as emotions, play, physical experiences and aesthetic modes of expressions. Seeking to contribute to the discussion of what early years science education can be, our aim is to examine if and how elements of scientific literacy are combined with multi-dimensional teaching in pre-school activities.

Scientific literacy and emergent scientific literacy

'Emergent science' relates to a general idea of 'emergent learning': that is, the idea that children discern qualities that are essential to learning something in particular (Pramling & Pramling Samuelsson, 2008). One example is 'emergent literacy', which is about discerning qualities such as the fact that words consist of letters, or in what direction we read, which is essential to eventually learning to read (*ibid.*). When it comes to science, the emergent learning can be about discerning meaningful qualities of the science phenomena that are under investigation. For example, experiences that help children discern how different items sink or float are meaningful to eventually learning the abstract science concepts 'density' and 'buoyancy' (Larsson, 2016).

What we are proposing is an 'emergent scientific literacy' that builds on the ideas of emergent learning (Pramling & Pramling Samuelsson, 2008). Scientific literacy has been used broadly in the latest decades, by various stakeholders in education, to address what science education should consist of in order to foster citizens equipped for the contemporary society (Roberts, 2007). Roberts has proposed that the concept 'scientific literacy' could be understood somewhere on a continuum between two 'visions'. Vision I points at being literate in relation to specific content knowledge and processes *within* the science community, while Vision II addresses the ability to handle science-related situations in a larger, societal context. In this article, we focus on scientific literacy closer to Vision I: being literate in relation to how the natural world works and in relation to the scientific methods of gaining knowledge about how the world works.

Our reason for adding 'emergent' to 'scientific literacy' is that we need a concept suitable to the pre-school's conditions in order to meet our aim to examine if and how elements of scientific literacy are combined with multi-dimensional teaching in pre-school activities. We propose that the characteristics of pre-school science practice might go unnoticed if we employ a school-oriented framework for distinguishing scientific literacy. In 'emergent scientific literacy', we include the emergent qualities of natural, chemical and physical phenomena that children experience prior to grasping the scientific concepts. For example, we consider children's experiences of pushing and pulling as emergent qualities prior to learning the abstract concept 'force' (Sikder & Fleer, 2015). Further, we include emergent qualities of scientific methods, such as observing, posing hypotheses, making inference based on empirical studies, and making models and other representations. Since our research builds on data from Swedish pre-schools, the national context is outlined below.

The Swedish context

Swedish pre-school practice builds on the idea that learning, fostering and care are intertwined and equally important. As in many other countries, the pre-school's responsibility for learning has been strengthened in the last decade. When it comes to science, the curriculum states that pre-school should strive to ensure that each child develop their interest and understanding of the different cycles in nature, how people, nature and society influence each other, and science and relationships in nature, as well as a general knowledge of plants, animals, chemical processes and physical phenomena (National Agency for Education, 2011). Also, the children should be encouraged to develop an ability to distinguish, explore, document, pose questions and talk about science (*ibid.*).

In Sweden, 83% of all children aged between 1-5 years are enrolled in pre-school and the common case is that teams of 3-4 educators work with a group of 15-20 children (National Agency for Education, 2016). The staff typically consist of several professional categories, of whom an average of 40% are pre-school teachers (*ibid.*). Though the pre-school teachers have a special responsibility for education in Sweden, all staff are responsible for both education and care.

Noteworthy is that Swedish pre-school is an example of institutionalised science education for children from the age of 1 year. This is rare from an international perspective, where science education most often targets children from 3 years and older (Sikder & Fleer, 2015).

Methodology and methods

Our data were collected in fourteen different pre-school units in Sweden. We selected the pre-schools because they had reported that science was a significant part of their practice. Three pre-schools volunteered to join after a lecture held by one of the authors. The remaining eleven were picked based on their responses to a large-scale questionnaire. We visited the pre-schools on four to ten occasions (97 in total) in order to observe and document both planned and spontaneous science activities. We also conducted stimulated recall group discussions (12 in total) and individual interviews (20 in total) with the teachers in these pre-schools.

We have previously used Activity Theory (Engeström, 1987) as a theoretical framework to analyse how cultural factors interacted with the shaping of the science activities in these fourteen pre-schools. This meant that we studied the videotaped activities, as well as group discussions and interviews with teachers, to discern the following seven elements: *subject, object, tools, rules, community, division of labour* and *outcome* (Sundberg *et al*, 2016). Our analyses resulted in one 'activity system' for each pre-school, including descriptions of the seven elements and how they interacted in the teacher's shaping of science activities. In this article, we revisit the activity systems to respond to the following analytical questions:

1. Were elements of emergent scientific literacy visible in the activities?
   a) Emergent qualities of scientific methods
   b) Emergent qualities of physical, chemical, or natural phenomena
2. If so, what teaching dimensions were visible in these activities?

In order to respond to the questions, we conducted a thematic content analysis of the material and communicative *tools*, the *object* (the purpose), and *the outcome* of the observed activities. For example, we followed a pre-school whose science activities were framed within a 'rolling and spinning' theme.

The teachers' *object* was that the children learned 'as much as possible' and gained many personal experiences of rolling and spinning motions. In terms of *material tools*, they supplied children with a large variety of everyday objects that could spin and roll as well as ramps and other material whose incline and surface the children were able to change.

In terms of *communicative tools*, the teachers used gestures and verbal communication to draw attention to children's achievements and discoveries, and to encourage children's further explorations. The pre-school's activities included rolling marbles through paint on a tray, treasure hunting for examples of rolling and spinning in the surroundings, rolling car tyres up and down a hill, and rolling oneself down a hill. The overall *outcome* was that children were afforded many different experiences of rolling and spinning motions.

In terms of elements of emergent scientific literacy (analytical question 1), we discerned the following themes through our content analysis of this pre-school's activities:

a) *Emergent qualities of scientific methods*: Observing similarities and differences; comparing and contrasting how items roll, depending on the incline.
b) *Emergent qualities of physical phenomena*: Concepts enfolded in rolling and spinning motion, such as friction, and the relation between the incline and the shape and speed of the rolling item or child.

In terms of teaching dimensions visible in these activities (analytical question 2), we discerned the following themes:

- *Fantasy and play:* Treasure hunt for things that spin and roll.
- *Aesthetic modes of expression:* Marble painting.
- *Embodiment:* Experiencing what it feels like to roll oneself down a hill and to roll a tyre up a hill.
- *Systematic inquiry:* Rolling marbles down ramps with different inclines.

Findings

By analysing activities from all fourteen pre-schools in our data set, we have found examples of the following teaching dimensions in activities that include elements of emergent scientific literacy: *fantasy and play*, *empathy*, *aesthetic modes of expression*, *storytelling*, *embodiment/sensory experience*, and *systematic inquiry*. In Table 1 (overleaf), we present the results through examples of common combinations of teaching dimensions and elements of emergent scientific literacy.

The examples are selected from: the 'rolling and spinning theme' that we discuss above; the snapshots presented in this article's introduction; and three pre-schools that we will describe in more detail below. In the table, we exemplify 'emergent qualities of scientific methods' with 'making models' and 'observing differences and similarities'.

Other examples, not included in the table, which we have identified in the pre-school's activities are: repeated trials, changing one factor at a time, posing hypotheses, drawing conclusions based on evidence, and making visual representations.

Frottage art to learn about the different tree barks

In one pre-school, for children aged 4 to 5, the teachers brought crayons and sheets of paper to the forest. The children were encouraged to do 'frottage art', putting the paper on the trunk of a tree and drawing gently with the crayon so that the structure of the bark resulted in a pattern on the paper. The children were also encouraged to touch the surface with their own hands and to compare what the bark on different trees felt like.

In this activity, we identified the following elements of emergent scientific literacy:

a) *Emergent qualities of scientific methods:* to observe similarities and differences (between the bark of different trees).
b) *Emergent qualities of natural phenomena* (the composition of a tree): the structure of a tree's bark.

Further, we identified that the main teaching dimensions were aesthetic modes of expression and sensory experiences.

Storytelling and examining figures sticking to a woollen blanket

In another pre-school, for children aged 1 to 2 years, the teachers arranged for a storytelling moment during a visit to the forest. The story was about a child going on a sleigh on an icy lake and, while reading, the teacher placed different toy figures on a woollen blanket: for example, a small sleigh and a plastic snowman. Since there was some snow on the ground that day, the teacher made a real snowman too, adding it to the scenario on the blanket.

At the end of the story, the teacher noticed that the snowman that was made of snow stuck to the blanket. Realising that this was something special, the teacher demonstrated several times how the snow-snowman stuck while the plastic snowman did not. She asked the children for suggestions of other things that they wanted to test to see if they would stick to the blanket. One child pointed at moss on the ground and the teacher asked each child if they thought the moss would stick or not before she tested (it did not stick).

Table 1: In the table, examples of pre-school activities are inserted in cells that represent the elements of emergent scientific literacy and the teaching dimension discerned in the activity. The table builds on the empirical examples provided in this article, not a comprehensive picture of possible combinations of elements of emergent scientific literacy and teaching dimensions. Hence, the fact that some of the cells in the table are blank should not be read as this being an impossible combination in pre-school.

	1. Emergent scientific literacy (examples)				
	a. Emergent qualities of scientific methods		b. Emergent qualities of science phenomena		
2. Teaching dimension	**Making models**	**Observing differences and similarities**	**Physical phenomena**	**Chemical phenomena**	**Natural phenomena**
Fantasy and play	Playing inside a model of the inside of a tree	Letter correspondence with a tree fungus about its eating habits, compared to how the children eat	Treasure hunt: finding things that roll and spin		Fantasy and play connected to the relationship between fungus and tree; how the fungi 'eat'
Empathy	Creating a nest for a magpie				Rejecting the notion that a tree fungus be cut down from a tree
Aesthetic modes of expression	Creating models of organisms in clay or papier-mâché		Rolling marbles through paint		Frottage art: drawing on a paper put on a tree trunk
Storytelling		Storytelling using figures of different material, which stick/do not stick to a woollen blanket			Teacher telling stories about how mushrooms eat
Embodiment/ Sensory experiences		Comparing what the bark of different trees feel like	The feeling of rolling oneself down a hill or rolling a car tyre up a hill	Properties of snow; tasting, touching and listening to snow	Sensing the structure of the bark of a tree
Systematic inquiry		Rolling and spinning different objects, in different settings, through controlled trials	Concepts tied to rolling and spinning motion, such as, friction, surface, incline and shape	'Sticking ability' of plastic, snow, moss and wool	

In this activity, we identified the following elements of emergent scientific literacy:

- *Emergent qualities of scientific methods:* repeated trials, changing one factor at a time, observing differences, and posing hypotheses (regarding how different material stick to wool).
- *Emergent qualities of chemical phenomena* (properties of various materials): 'sticking ability' of plastic, moss, snow and wool.

We identified that the main teaching dimensions were storytelling and systematic inquiry.

Building a fantasy world around a tree fungus and exploring how fungi eat

In a third pre-school, for children aged 1-5, a group of children had noticed that fungi grew on some of the trees in the forest. They 'adopted' one of the fungi, named it 'Musli' and, over a long period of time, they and their teachers developed an imaginary world around the life of Musli and his relatives. The children showed empathy for the fungus, discussing whether Musli may be cold and bringing warm clothes to dress the fungus.

On one occasion, the teachers placed a letter 'from Musli' on the particular tree for the children to find, to introduce the question of what and how the fungus eats, in comparison to the children. In later activities, the teachers told the children about how the fungus injected thin threads into the trunk of the birch tree, and that nutrients were transported from the birch to the fungus through these threads.

Following up on the 'food question', the teachers helped children to roll a big piece of paper into a cylinder, making room for as much as three children on the inside. The children then drew directly on the cylinder-shaped paper what they thought the inside of the tree might look like, hence creating a model of a tree trunk. Since it was big enough for children to fit inside it, the tree model became a site for playing.

On one occasion, the teachers brought a fungus (not 'Musli'!) to the pre-school for the children to touch and observe. Afterwards, the children made their own papier-mâché models of the fungus. Previously, the children had demonstrated that it was unthinkable to cut Musli or some of his relatives down from their trees, because it would be too cruel.

In this activity, we identified the following elements of emergent scientific literacy:

- *Emergent qualities of scientific methods:* making models (of the inside of a tree) and observing differences (between how fungi and children 'eat').
- *Emergent qualities of natural phenomena* (the relation between fungi and trees): how fungi 'eat'.

We identified many dimensions of science teaching: fantasy and play, empathy, aesthetic modes of expression, storytelling and sensory experience.

Discussion

The results contribute important perspectives to the discussion of what pre-school science can be, showing that elements of emergent scientific literacy can be combined with a wide range of teaching dimensions, such as empathy, fantasy and storytelling. In the studied pre-schools, there are no obvious signs of 'schoolification' in terms of compulsory school standards imposing a 'downward pressure' on pre-school education (Moss, 2008). Rather, the teachers seem to have found ways of shaping science activities that are in line with the multi-dimensional pedagogies characteristic of pre-school practice (Klaar & Öhman, 2014).

We put forward our analytical questions, and the teaching dimensions displayed in Table 1, as a possible tool for teachers to plan or evaluate their science teaching; what emergent scientific literacy are the children afforded, and what teaching dimensions are part of the science activities? Recognising that the concept 'emergent scientific literacy' captures elements in pre-school science teaching that would otherwise go unnoticed, we also suggest the concept as a methodological contribution to this field of research, supporting analysis and descriptions suited to the conditions of pre-school practice.

The multi-dimensional science teaching that characterises the studied pre-schools implies that *'a child's whole being, mind and body, are used in the learning process'* (Westman & Bergmark, 2014, p.78), which in turn caters for solid engagement and learning in science. Still, our analysis does not capture *what* the children learn. Therefore, if teachers use our analytical approach to plan and evaluate their science teaching, it needs to be accompanied by a plan of how to capture and support children's learning. We stress this since researchers have pointed out that pre-school children are often left to discover the surrounding world on their own, lacking the instruction necessary to make scientific meaning of their discoveries (e.g. Fleer and Pramling, 2015). Further, research has shown that teachers' science learning goals are obscured as an effect of their prioritising other goals (Sundberg *et al*, 2016) or as an effect of teachers' will to address every child's comment or to address fantasy and play in their communication about science content (Gustavsson *et al*, 2016). This article points at the *potential* of multi-dimensional teaching for emergent scientific literacy in pre-school. However, in order for learning to take place, teachers need to hold on to their science learning goals and help children to make scientific meaning of the emergent qualities of science phenomena that they experience. Otherwise, the emergent scientific literacy risks suffering defeat in the multi-dimensional competition of everyday life in pre-school.

References

Areljung, S., Ottander, C. & Due, K. (2016) '"Drawing the leaves anyway": Teachers embracing children's different ways of knowing in preschool science practice', *Research in Science Education*, **47,** (6), 1173–1192

Engeström, Y. (1987) *Learning by expanding: an activity-theoretical approach to developmental research.* Helsinki: Orienta-konsultit

Fleer, M. & Pramling, N. (2015) *A cultural-historical study of children learning science: Foregrounding affective imagination in play-based settings.* Dordrecht: Springer Netherlands

Gananathan, R. (2011) 'Implications of full day kindergarten program policy on early childhood pedagogy and practice', *International Journal of Child Care and Education Policy*, **5,** (2), 33–45

Gunnarsdottir, B. (2014) 'From play to school: Are core values of ECEC in Iceland being undermined by "schoolification"?', *International Journal of Early Years Education*, **22,** (3), 242–250

Gustavsson, L., Jonsson, A., Ljung-Djärf, A. & Thulin, S. (2016) 'Ways of dealing with science learning: a study based on Swedish early childhood education practice', *International Journal of Science Education*, **38,** (11), 1867–1881

Klaar, S. & Öhman, J. (2014) 'Doing, knowing, caring and feeling: Exploring relations between nature-oriented teaching and preschool children's learning', *International Journal of Early Years Education*, **22,** (1), 37–58

Larsson, J. (2016) 'Emergent science in preschool: The case of floating and sinking', *International Research in Early Childhood Education*, **7,** (3), 16–32

Moss, P. (2008) 'What future for the relationship between early childhood education and care and compulsory schooling?', *Research in Comparative and International Education*, **3,** (3), 224–234

National Agency for Education (2011) *Curriculum for the Preschool Lpfö 98*: *Revised 2010*. Stockholm: Fritzes

National Agency for Education (2016) *Statistik om förskolan [Statistics about Preschool].* Accessed 20 March 2018: http://www.skolverket.se/statistik-och-utvardering/statistik-i-tabeller/forskola

Pramling, N. & Pramling Samuelsson, I. (2008) 'Att skapa betingelser för och att följa små barns lärande'. In: *Didaktiska studier från förskola och skola.*, Pramling, N. & Pramling Samuelsson, I. (Eds). Malmö: Gleerups

Roberts, D.A. (2007) 'Scientific Literacy/Science Literacy'. In: *Handbook of Research on Science Education*, Abell, S.K. & Lederman, N.G. (Eds). Mahwah, New Jersey: Lawrence Erlbaum Associates

Sikder, S. & Fleer, M. (2015) '"Small science": Infants and toddlers experiencing science in everyday family life', *Research in Science Education*, **45,** (3), 445–464

Sundberg, B., Areljung, S., Due, K., Ekström, K., Ottander, C. & Tellgren, B. (2016) 'Understanding preschool emergent science in a cultural historical context through activity theory', *European Early Childhood Education Research Journal*, **24,** (4), 567–580

Westman, S. & Bergmark, U. (2014) 'A strengthened teaching mission in preschool: Teachers' experiences, beliefs and strategies', *International Journal of Early Years Education*, **22,** (1), 73–88

Acknowledgement

The research presented here is part of a larger project funded by the Swedish National Research Council (VR-UVK). The authors would like to thank their partners in the project, Kenneth Ekström, Karin Due, Christina Ottander and Britt Tellgren.

Sofie Areljung and **Bodil Sundberg,**
Örebro University, Sweden.
E-mail: sofie.areljung@oru.se and from August 2018: sofie.areljung@umu.se