Science practices as a tool for spotting and supporting children's investigative actions in Early Childhood Education and Care (ECEC)

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Abstract

Science in Early Childhood Education and Care (ECEC) has, in many contexts, recently taken a shift in focus from science content towards science processes. This approach builds on an enquiry approach to science in schools. However, school science and emergent science is not the same and science practices from school cannot be translated directly into the ECEC context. This study shows how a set of science practices developed in and with ECEC practice can help ECEC staff to identify and support science, not only in prepared settings, but also in children's spontaneous play. Through two illustrative cases, the study shows how science practices can help ECEC staff to develop their language in science while also offering science practice as an analytical tool for both practice and research.

Introduction

In the western world, there is a societal focus on how to support children's interest in and motivation for science (natural phenomena) in the early years (Eshach & Fried, 2005; Eshach, 2006). The American reform in the field of science is primarily rooted in *A framework for K-12 science education* (National Research Council, 2012) and the *Next Generation Science Standards* (National Research Council, 2013) and marks a shift in the approach to science from 'learning about science' to 'find out with science' (Larimore, 2020), which has also influenced school curricula in the rest of the Western world. Although these standards focus on science education in school, they also have a large impact on how science looks to children aged 0-6 years (Wilinski, 2017).

Play and curiosity is a main focus in Early Childhood Education and Care (ECEC) and child-led investigations are common. However, science in ECEC contexts is still mostly related to specific adult-chosen science content. Even when we want children to play with science, it becomes instructive and the play activities are prepared by the adults in order to address specific science content (e.g. Bonawitz *et al*, 2011; Bulunuz, 2013; Fleer, 2022; Vartiainen & Kumpulainen, 2020).

Fleer (2022) argues that the approach to science starts with either a sensually science phenomenon, e.g. a rainbow or dew on the grass, or the abstract science concepts such as the refraction of light or state forms of water. In this article, we direct our attention to 'how do we do science?' instead of 'what science should we learn?'. We therefore focus on how and where the children do enquiry and how ECEC personnel underpin such enquiry activities. This approach is supported by Haug, Sørborg and Mork (2021), who argue that we need to focus on science practices in science education and not just on enquiry. Likewise, Johnston (2013) argues that we need to have the same focus in an ECEC context.

In a design-based study on science practices in a Danish ECEC context (Ahrenkiel, Petersen & Jørgensen, in prep.), we identified eleven different science practices (see the section below). The study was conducted as an interplay between field observations in 17 institutions and developmental workshops (n=8) with pedagogical staff from the institutions. The concept of science practices can help to clarify which actions children in ECEC carry out in situations with science, and characterises an investigative approach, thus giving us opportunities to spot and support children's investigative actions. In this article, we use these practices to analyse science activities in ECEC.

The research question is as follows:
How can science practices be used as an analytical tool for informing about children's enquiry in science activities?

First, we give a short introduction to the science practices, followed by two cases as analytical examples. Then, we discuss the possibilities and limits of using science practices as a tool.

Science practices

When Haug, Sørborg and Mork (2021) argue for an approach towards science practices instead of the overarching concept of enquiry, it is a way to make school science more concrete. This is also a challenge for the Danish ECEC context, but a significant difference between ECEC context and school context is that, while teachers in school are specialised within domain knowledge of science, ECEC personnel are specialised within general pedagogy and child development. The Danish pedagogical curriculum in the field of ECEC (ECEC covers both public and private childcare services for children aged 0-6 years) was revised in 2018 (Ministry of Children and Education, 2018). While the original pedagogical curriculum had emphasis on nature and natural phenomena, the revised curriculum now included a specific focus on an investigative science approach. Some of the central elements in the revised pedagogical curriculum are that the children's own curiosity, children's communities and play must be central. In both the former and current pedagogical curriculum, there is a focus on children's curiosity, wonder and active participation. The difference therefore consists primarily of the investigative science approach becoming an explicit part of the pedagogical curriculum.

A number of challenges is associated with working with science phenomena and science concepts (Barenthien, Oppermann, Anders & Steffensky, 2020; EVA, 2015). In a Danish context, science can lead to diffuse understandings of what a scientific approach is. In this article, we present our work in developing a concept of science practices for children aged 0-6 years, which can be used by ECEC staff in practice, and which focuses on actions. A large part of children's experiences take place through bodily actions and sensory impressions (Fredens, 2018). Here, science practices become an opportunity to connect children's sensory and bodily actions with science phenomena and concepts.

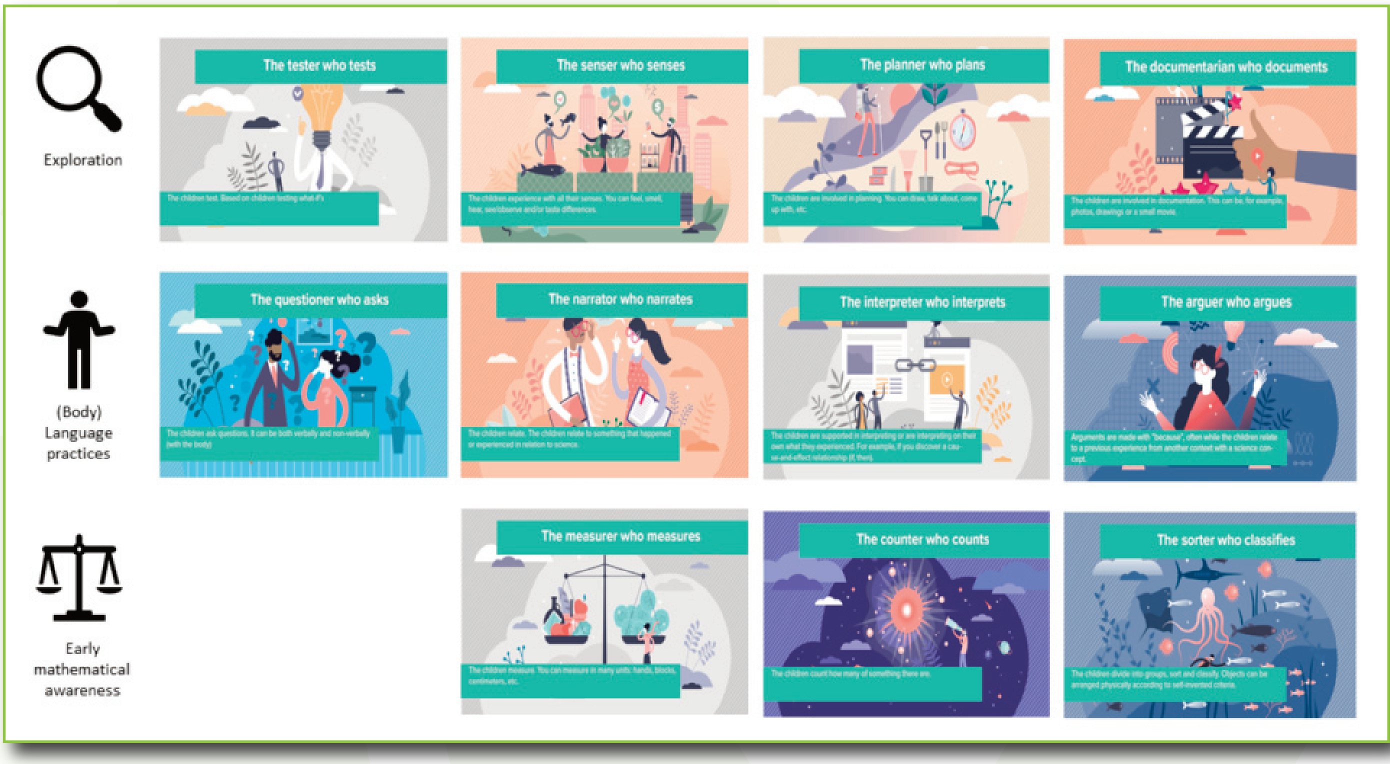
Science practices as an analytical tool

When we direct our attention to what children *do*, it becomes concrete and possible to observe, analyse and develop science situations in ECEC contexts. So far, we have identified eleven science practices within three dimensions: A dimension for exploration, a dimension with (body) language and a dimension on early mathematical awareness (see Figure 1).

The dimension for exploration is characterised by four distinct science practices:

- *The tester who tests* is seen when children are testing (something) based on 'what if'. The practice is a widespread science practice and, for instance, takes place when a child tests where a piece of magnetic toy sticks.
- *The senser who senses* takes place when children experience science phenomena and concepts with all their senses: feeling, hearing, seeing/observing or tasting differences. The word *differences* is important, as it is an attention hereto that makes the practice a part of a dimension for exploration. The senser who senses can be seen, for example, when tasting different fruits and talking about the similarities and differences in taste that the child experiences.
- *The planner who plans* is about involving the children in planning science activities. You can draw, talk about, or find materials together. The practice reminds us that, together with children, we can discuss 'how could we do it? What do we need in order to ...?', etc. The practice is less widespread in Danish ECEC settings, where we find that ECEC staff often plan or think ahead of the child in science situations – thereby, science easily appears as a planned activity and not as a spontaneous part of the ECEC everyday life. However, the practice is very relevant to supporting the child in becoming able to explore and to raise curiosity.

Figure 1. Eleven science practices in three dimensions
(available at: https://www.ucviden.dk/files/180080765/Sciencepraksisser_p_engelsk.pdf).



- *The documentarian who documents* takes place when involving children in documenting science phenomena or concepts, such as taking pictures of a plant from seed to fruit. This practice is known from research contexts, e.g. laboratory journals. In an ECEC context, it is about documenting in different ways via photographs, drawings, etc., which gives children, parents and ECEC staff the opportunity to return to and talk about what they did and experienced in a science situation.

The dimension of (body) language takes into account that children express themselves to a greater extent with their body (non-verbal) than with verbal language. It can be seen, for example, in:

- *The questioner who asks*, where the child asks questions with their whole body, e.g. when pointing, shaping the mouth as an 'o', and/or directing wide-open eyes at a phenomenon.
- *The narrator who narrates* is about children narrating and relates to something that happens or has happened in relation to science phenomena or science concepts.
- *The interpreter who interprets* takes place when children either make their own interpretations of what is taking place, or are supported in interpreting, e.g. a cause-and-effect relationship where a child discovers and expresses 'If I change the slope, the ball rolls'. This practice is characterised by 'if, then' realisations.
- *The arguer who argues* is characterised by 'because', for instance when the children relate to a previous experience from another context with a science concept or phenomena.

The dimension on early mathematical awareness has three science practices:

- *The measurer who measures* is about spotting and supporting situations where measurements are made. The measurement can take place in all units: hands, feet, blocks, centimetres, etc. This science practice takes place when we measure how far a car travels, for instance.
- *The counter who counts* is about counting. This practice could take place during a meal where children count how many cups we need, how many children are not in today, etc.
- *The sorter who sorts* is about objects being grouped, sorted and classified according to different criteria (preferably some that the children come up with).

In the following sections, two cases from field studies are given as analytical examples.

Case 1 How much water can a nappy absorb?

'What is this?', an ECEC staffer asks. 'A nappy', a child says from around the table. 'What is it used for?', the ECEC staffer carries on. 'Peeing', another child responds. 'How much water do you think a nappy can absorb?', the ECEC staffer continues. '4!', a third child quickly responds. 'What if we pour water in the nappy?', the ECEC staffer asks. The children are provided with pipettes and two different measuring cylinders. The children add blue food colouring to the water to make it more visible. They are focused and concentrated on pipetting for quite a while. They are helping each other out with how to suck the water into the pipette. When the graduated cylinders get used, they are eventually thrilled. More and more water is absorbed into the nappy. The children lift the nappy: 'Is it heavy or light?', 'Is it dry or wet?'. The ECEC staffer supports the children's actions with questions. The children squeeze the nappy, lift it, pour more water, and so on – constantly observing and expressing what happens when they do it.

'Why does the water not run out of the nappy? What is hidden inside the nappy?', the ECEC staffer asks. A moment of suspense and doubt: 'A teddy bear!', one child says. Another suggests 'A horse-teddy-bear?'. 'How can we find out what is inside?'. 'Scissors!', a child replies. The children go to get scissors to open the nappies. One child is talking to the nappy: 'Now, you oldie – I shall cut you out', as if he is fighting with something inside the nappy. Eventually, the 'nappy-stuff' (sodium polyacrylate) comes out. The children touch it and the ECEC staffer asks 'How does it feel?'. 'Wet! Cold!', the children reply. When the material in the nappy is on the table, so much happens. The material is poured from one cylinder to another, pipettes are lowered into the blue matter and one child observes the reaction to that action. The matter is popping up. 'Wow!'. The talk is about solid matter, fluid, etc. The children are constantly repeating actions, imitating each other – expressing surprise and wonder, exclaiming: 'OH! – LOOK! – LOOK at mine!'. There is no sign of an end to this wonderful mess.

In this case, the children experience two prominent dimensions for exploration: first, *The tester who tests* when the children investigate what is inside a nappy, or what happens when blue-coloured water is added to a nappy. Based on the imaginative *what if*, the children test what happens. Second, *The senser who senses:* the children experience with their senses – wet, cold, etc. The children notice and talk about it, supported by the ECEC staffer.

The dimension of (body) language is also present in the case. The children ask non-verbal questions when they observe the nappy absorbing the water. 'How can this be possible?' – this is *The questioner who asks*. *The interpreter who interprets* is also present when the children say that there can be a teddy bear inside the nappy. They interpret the softness of a nappy as being like a teddy bear, which they know as soft.

The dimension on early mathematical awareness is present as *The counter who counts,* when the children count – for example, the amount of water that they pour into the nappy.

Together, the analysis with science practices illustrates a picture where all three dimensions of science practices are present. The analysis can be used by the practitioner to identify science practices both in planned activities and in children's spontaneous play. From this, the practitioner can scaffold children's learning in the situation. From a research perspective, the analysis with science practices offers knowledge of the specific context and of which science practices are present. This could be, for example, as part of a mapping of science context quality. This could be, for example, as an analysis of the presence or absence of specific science practices, or it could be as an analysis of how science practices appear together in different science contexts.

Case 2: Marble run

In the playground in an ECEC, Sigurd has stacked five large, soft Lego bricks on top of one another. He spots masking tape: 'What?', he asks. 'Masking tape', the adult replies. 'That', he points. 'Shall we use it?'. He nods. The adult pulls out tape, finds two tubes that can be taped together, and puts the two tubes on top of the bricks so that they balance. Sigurd brings a ball and puts it into the pipe. He notices that the ball does not roll in the horizontal tube. 'If you lift the tube, it will roll out.' Sigurd laughs and tries again. 'You have changed the slope', the adult says, as Sigurd picks up the tube. He repeats his action and the adult repeats: 'You have changed the slope. Sigurd changes the slope'. When Sigurd lifts the tube and the ball rolls downwards, he happily shouts: 'Sloooope!'. Sigurd is barely 2 years old and understands that his action creates a reaction and that changing the slope is the action that creates a reaction in the ball rolling. He does not understand the abstract physics concept of slope, but he does understand the concrete practice that is required for the ball to roll out of the tube.

In this case, Sigurd gains experience with the science phenomenon *marble run* and the physical concept *slope*. Furthermore, Sigurd carries out science practices when working with the marble run. Sigurd experiences dimensions for exploration in the science practice *The tester who tests*, when he tries to see if the ball will roll out of the tube with different positions/slope. *The senser who senses* is taking place when Sigurd is observing what is happening when the ball rolls out of the tube. Together with the ECEC staffer, Sigurd experiences *The planner who plans*, when they find masking tape and he directs the ECEC staffer with his body language (point and nod) and word 'That'. *The questioner who asks* is prominent when Sigurd asks 'What?' and when he repeatedly puts the ball into the tube, surprised and curious. The ECEC staffer supports Sigurd in interpreting what they are experiencing. They have discovered a cause-and-effect relationship (if, then), which the ECEC staffer articulates. In that way, the ECEC staffer acts as *The interpreter who interprets* for the child, and thereby helps to expand the child's vocabulary. At the same time, the ECEC staffer supports Sigurd in a future mindset of science practices and *The narrator who narrates*.

Together, science practices provide a basic picture of what actions can be thought of in constructive work with children in science situations. If situations with science give children the opportunity to take actions, then the science practices come into play around nature and natural phenomena.

Discussion and implications

In the two cases above, we have shown how science practices can be used to clarify the presence of science in children's activities. In the first case, we have a traditional approach to science with the ECEC staffer presenting the nappy to the children in a prepared set-up. Science is not hard to discover in such contexts when the preparation is focused on a science phenomenon or concept. The second case illustrates how science practices are present and can be identified in a less prepared and more spontaneous context. When analysing such a context, we find science practices in an equal amount as in the prepared setting. The usage of science practices as an analytical tool thereby offers the opportunity to open up the recognition of science in, for example, children's play and to support these practices in respect of the play. The practices thereby give the ECEC staff the opportunity to change focus from what can be done with this science phenomenon or concept towards a focus on children's actions and on what the science is in the practices that the children are doing. This of course implies that ECEC staff know the content and can interpret the context as science phenomena or concepts. A finding in the EPPE project (Sylva *et al*, 2004) was that *'freely chosen play activities often provided the best opportunities for adults to extend children's thinking'* (p.13). The science practices presented in this article offer a language to help adults to recognise and promote science in children's spontaneous science activities.

Another approach to the usage of science practices as an analytical tool is that the practices offer a mapping of the frequency of usage. ECEC staff are thereby offered the opportunity to see if their approach includes a wide span of practices, or if it is limited to a few. This calls for a long-range usage of the science practices that could be hard to implement on a daily basis.

Altogether, the science practices offer an expanded view on science and science activities for children, including play and spontaneous investigations. However, in order for them to be an effective analytical tool in reality, they require a systematic implementation among practitioners. In addition, science practices should not be seen as instruments for the checking of different practices. The use of this as a tool involves the ECEC staff in recognising practices, but also requires the same staff to scaffold and clarify the science content to the children.

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