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Preschool teachers' discussions of attempted play-responsive science teaching

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ABSTRACT

In this study, the theoretical framework of Play-Responsive Early Childhood Education and Care (PRECEC) and science in preschool is introduced in a Continuous Professional Development (CPD) project for preschool teachers. The aim of this article is to highlight opportunities and challenges for play-responsive science teaching based on a thematic analysis of eleven preschool teachers' discussions in various focus groups. In the analysis, three main themes have been developed, i.e. discussion about (1) the selection of the science content, (2) preschool teachers' ways of initiating play-responsive science teaching, and (3) children's actions in attempted play-responsive science teaching. The result showed that the content the preschool teachers intended to focus on in play and how the preschool teachers opened up for the activity to shift between *as if* and *as is* created both opportunities and challenges for play-responsive science teaching, and furthermore, what opportunities the children had of influencing the play. By using PRECEC as a theoretical starting point in discussions, opportunities emerged for preschool teachers to develop awareness of what happens in play, especially when they laboured to introduce science content. Furthermore, a shared professional language emerged by starting to use concepts from PRECEC.

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Play-responsive science teaching; early childhood education; professional development

Introduction

Play-responsive teaching (Pramling et al., 2019) is a relatively new way of approaching teaching in preschool, where play and teaching are seen as a mutual activity between preschool teachers and children. The aim of this article is to highlight opportunities and challenges for play-responsive teaching with science content based on preschool teacher's discussions in focus groups. Opportunities for children to explore science are everywhere, for example, by collecting pinecones in the forest, exploring how something sounds or feels, or spotting a rainbow (cf. Siry & Kremer, 2011; Tu, 2006). However, it is not enough to just create opportunities for children to explore science in their environment, for example, by encountering different materials. Fler (2009) highlights that children use materials provided by the teacher that are

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aimed at encouraging science exploration based on their experience of creating narratives, which might lead to other ways of using the material than what was intended. Therefore, the role of the preschool teacher is described as important for supporting children and also to make sense of the material provided in a playful context (Fleer, 2009). In this study, preschool teachers have participated in a Continuous Professional Development project (CPD) about play-responsive teaching and science content. Digital tools are, in some excerpts, used by the preschool teachers to represent science content in different ways. Still, the focus of the analysis presented here is play-responsive teaching, i.e. the preschool teachers' role in managing the creation of opportunities for science exploration and play while being responsive to children's perspectives (cf. Pramling et al., 2019). The research question guiding the analysis is: How do preschool teachers describe their experiences of initiating play-responsive teaching with science content?

In Sweden, preschool is a voluntary part of the education system for children between one and five years old, with 86% attendance in 2022 (Swedish National Agency for Education, 2023). According to the national curriculum, preschool teachers are responsible for the educational content of teaching, ensuring that this is in accordance with the formulated goals, including that each child is given the conditions to develop, play, and learn based on her or his ability (Swedish National Agency for Education, 2019). Also, teaching to provide 'each child with the conditions to develop an understanding of natural sciences, knowledge of plants and animals, and simple chemical processes and physical phenomena' is prescribed (Swedish National Agency for Education, 2019, pp. 14, 15)

Play-responsive teaching

Attempts to teach in accordance with the Play-Responsive Early Childhood Education and Care (PRECEC) framework (Pramling, 2022; Pramling et al., 2019) is referred to as play-responsive teaching. Teaching in PRECEC is conceptualised based on Barnett (1973) and rephrased by Pramling et al. (2019) as 'an intention to make possible for someone else/others to see/realise what oneself has seen/realised; responding to the response of the learner(s), that is, adjusting one's way of showing/explaining etc. to the understanding indicated by the learner(s)' (Pramling et al., 2019, p. 174). Hence, teaching is described as a mutual activity in which preschool teachers engage children to participate. All participants (teacher and children) are seen as equally important since teaching takes place in response to the responses of other participants. However, being responsive does not only mean following the will expressed by the children, the teacher's role is also to challenge the children in new directions or create new ways of playing. The preschool teacher could be both reactive by being responsive to children's play, initiatives and interests and proactive by giving children opportunities to experience things they may not have been able to do on their own. Teaching could then be seen as a mutually co-constructed activity, although the teacher is a more experienced participant in play that can support and challenge the children further (Pramling et al., 2019). The preschool teachers in this study are encouraged to join or initiate a mutual activity open for play, i.e. attempt play-responsive teaching with or about science content.

Exploring science in preschool

As stated above, there is a variety of opportunities for science in preschool depending on the structure, routines and the preschool teacher. However, it is proposed that it is not enough to create opportunities for children to explore science content by themselves (Fleer, 2009; Fleer et al., 2014; Tu, 2006). The importance of adult mediation is highlighted if the children are to pay attention to and explore science content provided in the environment (Fleer, 2009). Fleer et al. (2014) propose that preschool teachers who adopt a ‘sciencing attitude’ and consciously use science in their practice ‘provide children with experiences that engage them in science for a real purpose’ (p. 47). This aligns with Siry and Kremer (2011), who emphasise the importance of starting from what the children already know to approach the theories that the children have already acquired through previous experiences.

The importance of relating the exploration of science phenomena to children’s previous experiences is also emphasised by Fridberg et al. (2019, 2020). They use the concept intersubjectivity (cf. Rommetveit, 1974) to analyse the communication between teacher and child in the exploration of science. A mutual and simultaneous understanding between teacher and children is described as sufficient intersubjectivity (cf. Ivarsson, 2003) and means that the teacher considers both what children recognise and the intended object of learning. It can, however, be wrongly perceived that there is a mutual understanding between teacher and child in how the communication should be understood, which is described as illusory intersubjectivity. Fridberg et al. (2019) report that teachers and children may seem to be talking about the same thing, but when different meanings are attached to the concepts used, intentions can be misunderstood. When there is a break in intersubjectivity between the participants, it is not always acknowledged in the situation but emerges in a detailed analysis of the enacted teaching. In order to bridge breaks of intersubjectivity, such as misunderstandings of words, concepts or abstractions, Fridberg et al. (2020) describe how teachers can adopt and use intermediary objects of learning. These objects, such as different models, representations or abstractions (verbal metaphors), are features that children may need to experience along the way to understand the intended object of learning, e.g. act responsive as in play-responsive teaching.

Theoretical framework

The theoretical framework of Play-Responsive Early Childhood Education and Care (PRECEC) builds on empirically studying and theorising the interaction between preschool teachers and children where possibilities of supporting children’s learning and development within play are made possible (Pramling et al., 2019). In this study, the preschool teachers’ discussions are closely linked and based on the preschool teachers’ knowledge and experiences of PRECEC. Their discussions relate to both PRECEC and what they recognise and highlight as important when attempting to initiate play-responsive science teaching. Based on this, the concepts *as is* and *as if, triggering*, and *agency* from the theoretical framework have been selected to analyse the preschool teachers’ statements in the discussions.

Within the theoretical framework of PRECEC, a shared communicative activity like play can be described as characterised by the opportunities to talk about a phenomenon

as is and *as if* (Pramling et al., 2019; Vaihinger, 1924/2001). This can (in this study) mean exploring science content based on *as is*, exploring a phenomenon as it appears to the participants, or *as if*, where the phenomenon is embedded in imaginative play. Vaihinger (1924/2001) describes *as if* as a 'driving force' of play. To imagine things based on *as if* is crucial for being able to handle *what if*, which is described as the possibility to anticipate consequences or reactions. By shifting between *as if*, *as is* and *what if*, children adapt to different reasoning and ways of thinking.

Triggering is described as preschool teachers' actions, verbal or in other modalities, to influence a play-responsive teaching activity (Pramling et al., 2019). These actions can be directed at, for example, opening up to fantasise or exploring what in the play could be unexpected or unpredictable. Furthermore, the preschool teacher can *trigger* play by, for example, creating space for children in a mutual narrative, introducing opportunities to speak from the perspective of a character, or helping to direct the narrative in play. Triggering can also mean that the preschool teacher challenges the children with questions related to something that happens in the play or helps the children to meta-communicate about the play, i.e. 'shifting from talking and in other ways acting *within the play frame* to meta-communicating *about it*' (Pramling et al., 2019, p. 63).

The shifts in play between *as if* and *as is*, and how the participants negotiate the direction of play (alterity) can be seen as an opportunity for the child to distribute and redistribute *agency* (cf. Gillespie, 2012). Clarke et al. (2016) highlight the important role of the teacher in encouraging children's sense of agency, as well as their enacted agency in the activity. Furthermore, the preschool teacher can contribute to children's *agency* in play by inviting and creating space as co-creators of the narrative and by responding to the children's initiatives (Lagerlöf et al., 2019).

Research design

This study presented here is part of a Continuous Professional Development (CPD) project for preschool teachers about play-responsive teaching and science. The project is conducted at a preschool in southern Sweden, and a total of eleven preschool teachers participate. They all work at the same preschool but in different work teams.

The participating children are between one and five years old. They are part of either a younger children's group (1–3 years) or an older children's group (3–5 years). The preschool teachers participating in the project do not work continuously with a specific age group but follow the children from the time they start preschool until they leave and start school. This means that during the two-year-long project, some of the preschool teachers shifted from working in a younger children's group to an older children's group or vice versa.

In the two-year project, different forms of interventions, such as lectures based on the content of the project or reading an article (Pramling & Wallerstedt, 2019), were introduced at the start of each semester as shown in Table 1. Following the interventions, the preschool teachers discussed the content in a focus group, creating opportunities to relate content from these interventions with the preschool teachers' experience from their practice. Before an upcoming focus-group session, the preschool teachers attempted to initiate play-responsive teaching with science content in their own practice based on their understanding. The preschool teachers video documented the activity and

Table 1. The organisation of the CPD project.

Semesters	Project organisation
Semester I	Introduction by a lecture about PRECEC and science Focus group 1: Discussion about the lecture Attempts at play-responsive science teaching
Semester II	Focus group 2 (Y & O)*: Discussion with stimulated recall Reading of article (Pramling & Wallerstedt, 2019) Focus group 3: Discussion about the article Attempts at play-responsive science teaching
Semester III	Focus group 4 (Y & O): Discussion with stimulated recall Reading of article (Pramling & Wallerstedt, 2019) Focus group 5: Discussion about the article Attempts at play-responsive science teaching
Semester IV	Focus group 6 (Y & O) mixed: Discussion with stimulated recall Lecture about PRECEC and play with science content Focus group 7: Discussion about the lecture Focus group 8 (Y & O): Continued discussion about the lecture Attempts at play-responsive science teaching Focus group 9 (Y & O): Discussion with stimulated recall

*To clarify what age group the preschool teacher works in: Y for younger children, O for older children.

brought a selection of this documentation to the following focus-group session as a basis for stimulated recall (Geiger et al., 2016; Reitano & Sim, 2010). These focus groups with stimulated recall were organised in smaller groups, based on the age of the children in the group that the preschool teachers worked in at the time, see above and Table 1. Since it was the preschool teachers that video documented the attempted play-responsive teaching, the importance of stopping the video recording if a child would show signs of not wanting to participate was discussed. However, in the analysed material no incidents were reported where the children did not want to participate. The data analysed consists of 14 audio-recorded focus-group discussions, each lasting approximately one hour.

Analysis process

The preschool teachers' discussions about their practice, particularly when they describe their attempts to initiate play-responsive teaching with science content, are thematically analysed (Braun & Clarke, 2022). Initially, the audio recordings from the focus-group discussions were transcribed, and notes were made about analytical ideas or insights related to the dataset. The transcripts were then coded using NVivo™, where segments of the dataset that are potentially interesting based on the research question were identified (Braun & Clarke, 2022) and related to concepts of PRECEC (Pramling et al., 2019). The focus was on how the preschool teachers, throughout the project, discussed their experiences of play-responsive teaching with science content. The codes that seem to share a core idea or concept are compiled as clusters of codes to create initial themes. These broad themes were developed to organise and structure the analysis of the preschool teacher discussions (Braun & Clarke, 2022). The analysis has, as previously described, focused on how the preschool teacher's discussions relate to the shifts between *as if* and *as is*, their described intentions in the activity (*triggering*), and possibilities for children's *agency* that emerge from the discussion. Each researcher in this study has in different ways been involved in the process of analysing the data following the procedure described by Braun and Clarke (2022). Initially, discussions focused on the use of the analysis concepts and how they could be applied to examples of the transcripts.

The process of creating and developing codes and emerging themes by reviewing, refining, defining and finally naming the themes was qualitative, reflective and evolved during the discussions between the researchers.

Results

During the project, the preschool teachers, as previously mentioned, discussed and viewed video documentation showing some of their attempts to initiate play-responsive science teaching. These attempts are seen as a process, which means that not all attempts, from the perspective of the theoretical framework PRECEC, can be understood as play-responsive teaching. In the analysis, three main themes have been developed, i.e. discussion about (1) the selection of the science content, (2) preschool teachers' ways of initiating play-responsive science teaching, and (3) children's actions in attempted play-responsive science teaching. Within each theme, different aspects related to the theme are made visible, which are presented below as subthemes. Each subtheme is described based on selected examples from the preschool teachers' discussion. The preschool teachers are presented with fictive names followed by the number of the focus group and the age group they work in (see [Table 1](#)).

(1) Preschool teachers' selection of the science content

The preschool teachers describe how they engage children in different activities where they, over time, together explore a chosen science content. These explorations of science content are mostly directed towards biology, where they, for example, explore environments with different insects or other animals, or physics, where the children's attention is directed towards sound, air or the direction of light. There are also examples of exploring chemistry content by conducting experiments, for example, mixing baking powder and vinegar. Furthermore, the science content often has a connection to an overarching theme at the preschool. The preschool teacher's discussions about the selection of science content to introduce in play-responsive teaching are structured into two subthemes: (1a) based on previous explorations initiated by the preschool teacher, or (1b) responding to children's interest in science content.

(1a) Selecting science content based on previous explorations initiated by the preschool teacher

When the preschool teacher describes what science content they focus on in exploration, it is often described as 'we work with' or 'we are working on', for example, the ocean, photons, or sound. This subtheme is presented with two examples showing both opportunities and possible challenges of taking a starting point from a previous exploration. In the following excerpt, Cecilia describes how they (the work team) initiated an ongoing exploration of woodlice and observed children start to play or act as woodlice:

We have some woodlice as our project. And now we have gotten to know a little woodlouse buddy. Today we had, we have been into this concept of magnifying, so we have been working a lot with magnifying glasses and today we also added the web egg [digital microscope] to enlarge them. Then the bark has also been an exciting concept ... we started

talking about what bark is, and we have been looking for bark. The woodlice like bark and we have painted from bark, looked at what the colours of bark are and so ... a lot of bark, you say the word many times. And then now we have started to see that they (children) have started playing woodlice. It's kind of spontaneous ... But there are figures, ... Sometimes they've stepped into the role themselves, but most of the time they find characters. And it could be anything. There are some people like this who are different, who have different roles – they are woodlice. It's kind of interesting. (Cecilia, FG 8:0)

The use of expressions such as 'we work with' or 'we are in to' could indicate that the exploration is more directed towards exploration and teaching activities (*as is*) than play (*as if*). However, the use of the term 'we' when describing the exploration can indicate that the exploration is a collaboration as a group, preschool teachers together with children. Hence, the play that Cecilia initiated could then be a continuation of a joint exploration of the science content as well as in response to the children's play. In other words, play-responsive teaching that the preschool teacher initiates can be seen as one way of connecting prior exploration and play.

In another example, the preschool teacher also uses 'we are working with' as a way of describing the science content they are exploring together with the children. However, a predetermined focus in the exploration (*as is*) is described by Karin:

We are also working with autumn, or really, we are focused on the colours of nature. So there have been a lot of autumn leaves, autumn colours ... Collecting it, we've looked at it, researched it with the web egg [digital microscope] and magnifying glasses. Felt and watched and discovered that they crumble very much when the leaves have been inside for a while ... It is the colours in nature with a focus on leaves. Today when we were in the woods, of course we have directed their attention to leaves, because that is the most clearly visible now that they are starting to fall. But today, when we were in the woods, I felt that the children were collecting a lot more, and interested in other things. (Karin, 8:0)

The fact that it is the preschool teacher who chooses the science content does not necessarily mean that the children are not engaged in the exploration. The term 'we' is here used to describe how the preschool teacher, together with the work team, has directed the children's attention towards a chosen science content. In this statement, Karin highlights several different ways they have explored leaves together with the children, even if it is, based on this statement, predetermined and planned by the preschool teacher. When the exploration of science content is planned by the preschool teacher, the opportunities for the children to initiate a new direction (*alterity*) or, in other ways, influence the exploration of the chosen content could be seen as less likely unless the preschool teacher is open for this to happen. However, Karin observes that the children collect leaves and other things when they are in the woods. Furthermore, Karin describes the children's exploration based on what they do, i.e. what they explore *as is*. She stresses that she finds it difficult to create opportunities to play with this content:

I've actually thought about it, leaves and colours, how can you get a creative constructive play out of it on the children's ... That's where I got stuck ... when we just look at leaves, their veins and how they feel and how they colour shifts and we've looked at colours in general as well ... get it kind of into a yes (play). (Karin, FG 8:0)

In this example, Karin problematises the connection between science exploration and play. The description of the science content is connected to facts (*as is*), where Karin does not see opportunities for a shift to play (*as if*) and expresses that she feels stuck.

Based on Vaihinger (1924/2001), *as if* is described as a driving force of play. When the preschool teacher experiences difficulties connecting exploration to *as if*, this could be seen as a limitation for *triggering* play with or about science content. This may indicate possible challenges as the preschool teacher is focused on knowledge and exploration of the science content (as is), limiting the participants to shift between *as if* and *as is* in an open-ended activity.

(1b) Responding to children's interest in science content

In the statement above (categorised as 1a), exploration of science content was selected by the work team and in Cecilia's example, the children created their own play based on their joint exploration. In other statements, the children's perspectives and interest in selecting science content become more visible. One example of this is given below:

We've just been working on sound ... But we have finished that, but the children got in to air because air is very closely associated with sound, so we have continued a little bit, just started on air, can you see the air, can you feel the air? Does air take up space? So, we started in the woods yesterday a little slowly and then we had some reflection before we went out. Then today it was windy (Martina, FG 4:Y)

This statement shows that the exploration of science content can take a new direction when the preschool teacher responds to the change of interest that the children express. Here, the exploration of the science content is related to the interest that the children show and can be described by the concept *as is*. Martina describes how the new content (phenomenon), air, raises questions such as 'Can you see the air? Can you feel the air? Does air take up space?' The questions can be seen as a way for the preschool teacher to *trigger* the children's thoughts and perceptions of air, but also a continued exploration. Catching air in large plastic bags when they were outside allowed the children to explore air based on the question that Martina expressed. The activity took a new direction when the children initiated a play where the bags of air became a treasure in a play about pirates. This example recurs and is described in more detail when the preschool teachers' discussions about ways of initiating play-responsive science teaching are presented below.

(2) Preschool teacher's ways of initiating play-responsive science teaching

Participating in play was not self-evident for all preschool teachers, as discussed in a previous report of the initial discussions during the first semester of the project (Lund et al., 2023). When preschool teachers take part in play and bring a thought of science content with them, their role in directing the children's attention can be described based on the concept of *triggering* (Pramling et al., 2019). The preschool teachers are challenged to take an active role in play, i.e. to attempt play-responsive teaching and to create opportunities to explore or play with science content. However, the analysis shows that preschool teachers trigger different forms of play, where the science content has different purposes. The preschool teacher's discussions about their attempts are structured into two subthemes (2a) to trigger play with science content and (2b) to trigger play by acting as science content or constituent.

(2a) To trigger play with science content

As presented earlier, Martina described how the exploration of science content (sound) changed based on an interest shown by the children (air). Martina initiated an exploration in the preschool yard, where the children filled large plastic bags with air as a way to experience that air takes up space. The exploration of air inspired a play initiated by the children.

Then this continues, they keep catching air and feeling it. Then they began to collect it in a train, the bags of air. Finally, they had filled the last wagon with bags of air. Then they started playing, because then we've felt and experimented and such, then it goes into their pirate play ... They started playing that they are pirates ... They lie and sit and kind of have it in the play and feel the air and experience the air with their whole body. Then I'm standing there trying to be a bit wise (laughs), yes you know, but it went great. (Martina, FG 4:Y)

Here, Martina supports the children in exploring the science content by creating opportunities to experience that air takes up space. The openness of the activity creates opportunities for the children to play with the science content. However, Martina also describes her role as 'standing there trying to be a little wise (laughs), yes you know, but it went great'. This could be seen as a way of Martina being present in the children's play to continue to challenge the children with questions related to the play or to help meta-communicate about the narrative of the play or problems to be solved within the play (Pramling et al., 2019). But the statement also shows the complexity of joining or following the children in play when it takes a new direction. The children continued their exploration of air in play, but not on their own or as something separated from the activity.

Even if the exploration of feeling the filled plastic bags could be seen as exploring science content *as is*, Martina highlights how the children, when exploring, use their imagination by shifting from *as is* to *as if*. Martina reflects on how imagination could be seen as a part of the exploration:

But I think already there when they have caught the air and they see that ... Yes, there was someone who started playing (hitting) on them, because we have talked about sound before so 'oh, it sounds, it sounds'. I think there is a lot of imagination to think that this is a sound that I create when I am hitting on it. 'Do you hear, listen, it sounds' ... And that air, that they felt it and 'it is like a pillow'. There were a lot of thoughts even at that stage. (Martina, FG 4:Y)

Even if it is the plastic bag filled with air (*as is*) the children initiate an exploration where the content is used in another way, *as if* it were a drum or a pillow. In this way, both *as is* and *as if* become important aspects to consider, both in the exploration of science content, and the play. Other examples within this subtheme are play initiated with materials representing animals or where the participants pretend to be divers in the ocean.

(2b) To trigger play by acting as science content or constituent

Attempts to initiate play-responsive science teaching can be described as the preschool teachers *trigger* play, often through acting as science content. This may imply that they in

the play pretend to be different animals, such as woodlice in the woods or fishes in the ocean. In the following example, Emilia and Jenny have, in similar ways, initiated an activity about light where they, together with the children, pretend to be photons moving in the room i.e. acting as a science constituent. This is done by using a hula-hoop as a representation of a flashlight. When they pretend to switch on the ‘flashlight’ the children jump through the hula-hoop as photons. Emilia describes why they chose this mutual activity:

We started working with light. So, one day when we sat and talked about it, we talked about what was in the light and we got into photons. The children thought it was really cool with a new word, but it meant that we needed to make it a little more, to make it a little clearer to the children about what light is. We talked about the direction of light, that it moves straight ahead. Then we wanted to dramatise it in some way ... we tried to do this with a flashlight, that you are the light that comes through the flashlight. (Emilia, FG 4:O)

Emilia describes their intention of using play as a way of explaining photons and how these move straight ahead. Emilia uses the concept ‘dramatise’ to describe this, which can indicate that the narrative of the play is set in advance. To be able to play photons, the children need to imagine that the hula-hoop represents a flashlight and that they are the light travelling through the pretended flashlight. Although these parts can be related to *as if*, *as is* poses an important part of this play. The children need to jump through the hula-hoop (flashlight) and move straight ahead based on the importance of relating to knowledge about the phenomenon (*as is*). This example could be seen as a way of explaining or visualising science content, but there are limited opportunities for the play to take a new direction.

Even if the preschool teacher *triggers* a play acting as science content, it is not always certain what direction or how the play will continue. An example of this is when Cecilia initiated a play by projecting a close-up video from an anthill. To trigger the play Cecilia asks one of the children, ‘are you an ant?’ whereas the child replies, ‘no’. Viewing this video documentation started a discussion about the preschool teacher’s role and the importance of agreeing on how to play:

- Sara: I thought about it there too at the beginning when you asked, ‘are you an ant?’. It is just like, it is right at the beginning, and then I think if I just interpret the child ‘no, I am me’
- Martina: Yes, that is how I interpreted it to ...
- Sara: But you showed that you are an ant then all of a sudden, the child also thinks that it is perfectly ok to go into that fantasy, that you showed the way to it, so that it was very clear there And then it shifts out and in ...
- Cecilia: And I also think he was busy there, because he lies on his stomach and looks up at these ants, so I think he’s busy studying what’s going on there and what’s moving. So no, he wasn’t an ant, he did something else (FG 6:Y).

In this example, a challenge emerges for the preschool teacher to be open to what happens in the play and to coordinate different perceptions and actions that emerge when a play is initiated. Sara highlights the preschool teacher’s role by showing the way to go into fantasy (*as if*) by pretending to be an ant. The child, however, was not ready to fantasise about being the ant but has a focus on the exploration that can take place around an anthill.

(3) Children's actions in attempted play-responsive teaching

Based on play-responsive teaching, all participants in the activity are seen as equally important (Pramling et al., 2019). Play and exploration take place in response to each other meaning that the children's interests and initiatives are considered equally important as the preschool teachers' intentions. When the preschool teachers' discussion relates to children's actions in the activity, the concept of *agency* is used to draw attention to the opportunities created for the children in different ways enact their agency (Clarke et al., 2016) by for example co-create the narrative of the play (Lagerlöf et al., 2019), and develop the exploration. The subthemes presented here are (3a) children shifting between *as is* and *as if* in science activities, (3b) communication, children's verbal and nonverbal actions, and (3c) children's *agency* in attempted play-responsive science teaching.

(3a) Children shifting between *as is* and *as if* in science activities

When the preschool teacher has an intention to participate in play, and also introduce or focus on specific content, there needs to be an awareness of what happens in the play. Cecilia shares her reflections about children shifting between play and exploring in a discussion about what play is:

But it's probably a bit of us as human beings, that is, what we do in our professional role that we want to categorise, we want to put things into words And that's our profession, but if we take it away for a little while and just think about the little child, it's clear that then everything goes together. And then it's so hard to put these words on everything that's happening. Because they take on the whole world and they investigate, and they play, and they fantasise, and they discover. They do everything at the same time, of course. (Cecilia, FG 7:O)

There are various examples from the preschool teachers' attempts to initiate play-responsive teaching and their discussions where *as is* and *as if* is highlighted, but also how the activities shift between play and exploration. An example of this is the play Martina described, where the children initiated a play about pirates based on the exploration of air. Another example is when Cecilia attempted to *trigger* a play acting as ants in an anthill, but the children initially did not accept the role of an ant. Furthermore, preschool teachers, like in Karin's example, expressed difficulties in linking exploration (*as is*) with play (*as if*).

To further exemplify this, a video documentation from Helene showed a play with dinosaurs initiated by children. Helene described how she projected a picture of a dinosaur as a background in the play. Although the projected picture was intended to contribute to play, an exploration of shadows and patterns that falls on the hand when standing between the projector and the wall was initiated by the children. In the following discussion, different perceptions were expressed of how the children's actions could be interpreted:

Helene: He saw that he got this leopard pattern on his hand. That was what he was so fascinated by as he stood there. That was what the leopard hand was.

...

Jenny: They may have had slightly different interests, but they played anyway. But it was like you said that he tried something else there.

Karin: But it was not so much, or nothing at all, the dinosaurs. It was about the projection that you could get in different places, and the shadows (FG 6:O)

The intention in this activity, as expressed by Helene, was to project the picture in order to see if and how the picture could be part of the play. In the discussion, Jenny expressed that it is still play, unlike Karin who points out that the exploration now is about the projected picture (*as is*) and not within the play. This goes in line with Cecilia's description above, as the child 'take on the whole world and they investigate, and they play, and they fantasise, and they discover. They do everything at the same time, of course' (Cecilia FG 7:O). Based on this, the discussion can contribute to seeing how closely play and exploring is and how the activity can shift between these.

(3b) Communication, children's verbal and nonverbal actions

Based on the preschool teachers' experiences of attempting to initiate play-responsive teaching, verbal and nonverbal communication in the activity is a topic that the preschool teachers bring up on several occasions. When it comes to verbal communication, their reflections are mainly about how active they should be in order to make room for the children's initiatives, i.e. children's *agency*. One aspect of this is listening to questions raised by the children. Jonna describes how children often ask different questions, for example, what the children want to know about ants:

It was like if they talk or bite? If they can clap their hands? If it hurts if many bite at the same time? What kind of muscles do they have because they are so strong? There are many questions that you yourself do not think about and find out before, because the children ask different questions. (Jonna FG 7:O)

By taking a starting point from the children's questions in a mutual exploration, other interests emerge compared to when the preschool teachers plan on their own. In addition to this, Cecilia reflects on what competence preschool teachers need when attempting play-responsive teaching:

I also think about the competence that, especially if you are planning for play-responsive teaching, it is even more important that you do not forget to listen to the children. If it is a spontaneous moment then it is perhaps easy for us to end up on the same level, and we listen and let the children take the initiative. But just this, finding this interaction when I have planned something, listening to the children what they say and show and do, so that we end up on the same level. I think it's easy, especially when you have a planned situation, this is what we're going to do now, this is what we're going to

...

I also think it is important, because it takes a longer time to reach what you have thought you want to reach, but to dare to get to where you come and then do it again, and again. Add something, listen to the children so that you find it together with the children. (Cecilia FG 7:O)

In this example, the importance of listening to the children is highlighted, as an important part of 'ending up at the same level' as Cecilia expressed it, which also can create possibilities for children's *agency* in the mutual activity. Furthermore, when viewing video-documentations, discussion arises that there is a lot going on in the play that

they were not aware of when it happened. One aspect of this could be that the response from the preschool teacher often takes place based on the children's verbal communication as in this reflection:

I realise how much I miss when I am there, live, and then I only have three children. Sometimes I am so focused on one child, and then you watch the video and realise that he did that, and she did that. I think that so much happens nonverbally. (Cecilia, FG 4:Y)

Since the focus of this study is on the preschool teacher's discussions and not on the actual interaction between the preschool teacher and the children, the statement indicates that the preschool teacher sees new aspects of the interaction based on the video documentation. Based on PRECEC, responsive is, among other things, described as responding to the children's initiative and interest (Pramling et al., 2019). Cecilia's statement shows the importance of consciously paying attention to both verbal and nonverbal communication which could be seen as important for creating opportunities for children's *agency* in play.

(3c) Children's agency in attempted play-responsive teaching

The concept of *agency* has been used in the analysis to highlight what opportunities the children seem to have to influence the activity. In previous themes, discussions about children shifting between play and exploration, how or which science content becomes part of play, or discussions about communication show signs of children's *agency*. Further, the preschool teachers also describe how the children can develop the play by introducing new materials, or helping to organise the play by co-creating roles or the narrative, as in the following example where the preschool teacher and the children pretend to be in the woods:

... I actually heard that it was the boy in the patterned sweater who gave me the role of a shrew-mouse. I heard it at the beginning, that he said it. I think that was when I just got started, I thought 'ok, how can I think, that it is a little scared, little and small, why is it scared ...?' like that. Then I probably created it quickly in my head and spun on that. (Sara FG 9:O)

However, there are also examples of children's *agency* being limited, like when the narrative and science content in the initiated play is planned in advance by the preschool teacher or when the play is more focused on *as is*, as shown in the following example. Helene initiates a play about dinosaurs in the sandbox by conducting an experiment with baking powder and vinegar. Helene describes how this could be visualised as a volcanic eruption and a way to symbolise the extinction of the dinosaurs.

This may not have turned out quite what I had imagined, but ... They've been very interested in dinosaurs and volcanoes, so we had some experiments in the sandbox. There was a volcanic eruption, and all the dinosaurs died, then there was a meteorite, and then we humans came. So, they got to play it, but there may not be as much activity on their part. (Helene, FG 4:Y)

In this example, the narrative of the play was planned by Helene. Although the activity had a playful setting where dinosaurs from children's play were used, the children had limited opportunities to influence the narrative. Instead, the children initiated another play in the sandpit. Helene continues:

Then they play a little bit, but there wasn't a lot of play with it. It turned into another play in the sandbox ... After all, I feel that I was telling them what was going to happen (Helene, FG 4:Y).

Helene describes that the activity did not turn out as she had expected based on a notion of what was going to happen in the activity and a perception of how the children were going to act. The narrative of the play is based on the preschool teacher's knowledge of dinosaurs. Based on this, the activity could be seen as a playful way of explaining a course of events. However, in this example, the children chose to start their own play instead, which may indicate that there were limited opportunities for children's *agency* in the intended activity since they were not involved as co-creators of the narrative (Lagerlöf et al., 2019).

Discussion

Attempting to initiate play-responsive teaching could be described as a balancing act between *triggering* play towards a thought that the preschool teacher brings into play, and creating opportunities to act in response to the children's initiative. The aim of the article is to highlight opportunities and challenges for play-responsive teaching with science content based on preschool teachers' discussions. When analysing the opportunities and challenges that emerge from the preschool teachers' discussions, it is not always possible to separate them. To initiate or focus on science in play can create opportunities for continued exploration in play, but also induce a limitation when the science content is used as a narrative that limits the children's ability to influence the play. Based on play-responsive teaching, the interest is not directed towards who decides the content in the activity, but how the participants in the activity respond to each other (Pramling et al., 2019). However, descriptions of how the preschool teachers intend to link the exploration of science content with play-responsive teaching can indicate whose interest is the basis for the content in play and how the preschool teachers intend to link their exploration to an activity that is open to play.

The analysis of the preschool teacher's discussion showed that the science content the preschool teacher *triggers* in activities can be both about including science content in the play and by acting as science content. When the preschool teacher *triggers* a play where they pretend to be insects or other animals, there are opportunities to create a space for co-narration by considering the *as if* dimension (Pramling et al., 2019). Even if it is an imaginative activity where the preschool teachers and children pretend to be, for instance, an ant (*as if*), the *as is* dimension seems to be important in the play as the ant cannot act in any way they wish, the actions would be based on prior experiences of real exploration. Despite this, the narrative of the play is open to take a new direction, as shown in an example where the participants shift between acting as ants and exploring the anthill. In previous research, the importance of relating the exploration of science content to the children's prior experience (Fridberg et al., 2019, 2020; Siry & Kremer, 2011), and taking a starting point in what the children already know (Siry & Kremer, 2011) is highlighted. In this study, this may also mean considering the children's previous play experiences with the science content, for example, based on Cecilia's description that she takes a starting point both in a mutual earlier exploration and in the children's own play.

When limitations in attempted play-responsive teaching emerge, it is mainly when the narrative is predetermined by the preschool teacher, based on the knowledge of science content, i.e. how the photons move straight ahead or how the dinosaurs were extinct. The intentions of the play can then rather be described as dramatising a course of events in a playful way, where opportunities to include the children's play and exploration are limited. To initiate play-responsive science teaching the importance of creating an openness in the activity and the preschool teacher's consciousness of how the play shifts between *as if* and *as is* (Pramling et al., 2019) together with a sciencing attitude (Fleer et al., 2014) could be seen as crucial. The results show how closely play and exploration can be in an activity, which can create opportunities for children to shift between these in the same activity. Even if the preschool teacher has an idea about what content the play is initiated with, a play-responsive teaching approach can create opportunities for play and exploration in response to each other. In this way, it is not only the content that the preschool teacher intends to *trigger* a play about, but it can also be a challenge for preschool teachers to maintain or create an openness for the narrative to develop in a mutual play i.e. shifting between *as if* and *as is*.

Conclusions and implications

The results of this study show opportunities and challenges when preschool teachers attempt to initiate play-responsive science teaching. By using PRECEC as a theoretical starting point and discussing these attempts to initiate play-responsive science teaching, there are opportunities for the preschool teachers to develop an awareness of what happens in a mutual activity when they contribute by for example initiating or focusing on science content in play. PRECEC can therefore have an important role in the development of a scientifically based preschool education. It supports the development of a professional language with concepts that can be used in professional discussions about developmental work. Based on the promising attempts at play-responsive science teaching, further research focusing on children's perspectives of science including the interaction between children and teachers is needed.

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Ethics statement

The ethical considerations follow the recommendations of the Swedish Research Council (2017). All participants and caretakers approved their participation by signing a consent form. The consent form included information about the purpose of the study, and that

participation was voluntary with the right to withdraw at any time. All data generated from the focus groups will be kept confidential.

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