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How does gendering matter in preschool science

Emergent science, 'neutral' environments and gendering processes in preschool

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ABSTRACT

This article explores gendered processes in preschool science through Barad's agential realism [2007. *Meeting the Universe Halfway. Quantum Physics of the Entanglement of Matter and Meaning*. London: Duke Universal Press], and as such, the study makes both theoretical and empirical contributions in how it combines perspectives from emergent science [Siraj-Blatchford, J. 2001. *Emergent Science and Technology in the Early Years*." Paper presented at the XXIII World Congress of OMEP. Santiago, Chile, August 3], new materialism, and gender theory. Empirically, the study makes use of data constructed during a field study in a Swedish preschool with five-year-old children. The focus of the field study was the children's play and explorations together with the preschool environment, during activities not specifically guided by teachers. The analysis highlights how the children's identities and scientific explorations are made possible as well as constrained together with the preschool's material-discursive environment. As such, the study demonstrates how teachers cannot rely on any environment, activity, choice or subject content to be (gender) neutral.

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Emergent science and technology; gender; preschool environment; material-discursive; knowing-in-being

Introduction

Drawing on new materialist thought (Barad 2003, 2007, 2010, 2014) this study explores preschool children's scientific explorations and gendered becomings and thereby contributes knowledge about gendering to the field of emergent science. Although preschool science has received a lot of attention in many countries (see for example Cremin et al. 2015) and perspectives viewing science as social practices have been frequently used, there are still few studies within this field that focus on gender. Also in contemporary studies that use new materialist perspectives and view learning and becoming as

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mutual processes, gender has not been explicitly addressed. New materialist perspectives have made important contributions regarding how children's agency, learning, and becoming can be understood. Some studies have shown how gender is constructed in children's relations with the physical environments and the materialities in the preschools (see for example Blaise 2013; Hultman 2011; Lenz Taguchi 2010; Lyttleton-Smith 2017; Palmer 2011; Renold and Mellor 2013), while others show how materialities, as well as scientific contents in preschools, work as active agents which children learn *together with* rather than *about* (see for example Areljung 2019; de Freitas and Palmer 2016; Haus and Siry 2019; Taylor and Pacini-Ketchabaw 2015). However, there is a lack of studies with an explicit focus on both gender and science using new materialist perspectives, why this article aims to contribute with such knowledge by exploring the research questions below:

- How is the indoor environment of the preschool co-creating gendering processes as well as different possibilities to explore scientific phenomena?
- How do certain scientific phenomena take part in co-creating the children, their bodies and their relations with each other?

Emergent science

The concept of emergent science and technology was developed by Siraj-Blatchford (2001), with inspiration from the concept of emergent literacy (how literacy is constituted in young children's explorations). 'Emergent science' aims to shift the focus on learning science in preschool, from individual children's conceptual understanding of predetermined teaching content to science as a social practice, something already being explored by the children daily during play. The concept has been applied as a means to problematize the image of science as facts children need to learn in the 'correct way' and engage with how preschool children explore and co-create science (see for example Conezio and French 2002; Larsson 2013; Siry 2013; Tu 2006). For example, Larsson (2013) explored how children, without instructions from adults, found and engaged in explorations with friction in their everyday play and activities and Siry (2013) explored how children together developed complex investigations while exploring floating and sinking. Some studies use the concept with a deliberate focus on *science*, but it can be noted that the distinction between science and technology often becomes blurred in the context of emergent science.

To be able to provide nuanced explorations of children's doings of science and technology, studies point out the importance of not only focusing on scientific phenomena but also on aspects like children's way of problem solving, categorizing, measuring, sorting, and repeating elements (Eshach and Fried 2005) and other science inquiry skills such as wondering, asking questions, exploring, and formulating ideas and theories (Tu 2006). Even though emergent science puts a strong emphasis on children's own activities, studies also point out teachers support as crucial for children's learning, for example, when it comes to connecting children's play and explorations with scientific thinking and concepts (see for example Bulunuz 2013; Flear 2009) as well as arranging an environment that is rich with science equipment and materials (Eshach and Fried 2005; Tu 2006). Thus, to see materials as important for science learning is not exclusive for new materialist perspectives. The contributions made by the studies using a new materialist perspective is

not done by simply saying that matter matters, but rather by focusing on *how* matter matters, which we expound upon below.

Emergent science as material-discursive practices

Instead of *social-practices*, new materialist perspectives turn emergent science into *material-discursive* practices. That is, children are not seen as exploring science ‘on their own’ while they play, rather they explore and become together/entangled with the material-discursive surroundings. Of course, the children, ‘their’ agency and ability to construct (scientific) knowledge is of equal importance here as when thinking in terms of social-practices. What new materialist perspectives aim to shed light upon is that children’s possibilities for ‘doing science’ – for agency, learning, and becoming – is constantly dependent on their relations with their material-discursive surroundings. Instead of considering children’s agency as exclusively connected to human relations, it is also seen occurring in relations with nonhumans (Hultman 2011; Lenz Taguchi 2010, 2014; Westberg Bernemyr 2015). Areljung (2019) revisits empirical data from her earlier studies of preschool science (drawing on activity theory and cultural-historical contexts) together with Barad’s theory of agential realism and argues that when materials are seen as active agents which children learn and become scientific together with, learning possibilities that otherwise would go unnoticed (by adults) can be highlighted. In the re-reading of the data, it appears for example how the (frozen) ground in one of the studied preschool yards enabled or restricted the children from exploring, depending on the time of the year. Also, Haus and Siry (2019) underline the opportunities created when treating materials as active agents and science learning as human-nonhuman relations. They argue for the importance of open-ended explorations between materials and children, in which investigations of science phenomena, ‘which go deeper than initially defined by the teachers’ objectives’ (13), can occur. de Freitas and Palmer (2016) argue, drawing on the work of Deleuze, that scientific concepts – engaging specifically in the concept of force – can be understood as ‘creative playmates’ in children’s activities and learning. This means that scientific concepts not only are treated as contents to learn *about* but also as agents to learn and play *with*. Haus (2018) explores, inspired by de Freitas and Palmer (2016), how a boy and a sheet of paper becomes in new ways, the boy as a folder, maker and player and the paper as a plane, as they explore and play together with the concepts of force and flight. Not only physical phenomena (as scientific content) are highlighted as agents to learn with, but also for example nature and animals. Taylor and Pacini-Ketchabaw (2015) explore how learning occurs together *with* other species, in their case preschool children together with ants and worms. The results show how also the ants and worms co-created what directions the learning took.

The studies mentioned above take a stance that new materialism (or post-humanism) enables ‘new ways of becoming scientific’ to come to the fore. Becoming is thus important in all studies, however not explicitly gendered becomings.

Gender perspectives on science and technology in preschool

Studies using gender perspectives have mostly focused on teachers’ approaches and conceptions. For example, how teachers handle and combine traditional norms connected to

science (masculinity, objectivity, facts) with norms connected to preschool (care, femininity, intuition, subjectivity) (Areljung, Ottander, and Due 2016), pre-service teachers' reflections and different ways of identifying events related to gender and emergent science (Gullberg et al. 2018) and pre-service teachers' own (gendered) experiences from learning science and technology and how this affects their ability to teach science and technology to children (Andersson 2011; Andersson and Gullberg 2014; Hedlin and Gunnarsson 2014). These studies show that norms and discourses connected to science and gender affect teachers and how they teach, but that these aspects can be less determining if teachers combine scientific facts with children's subjective theories and explorations. Three studies which have the children in focus are Sullivan and Bers (2013), Patrick, Mantzicopoulos, and Samarapungavan (2009) and Hallström, Elvstrand, and Hellberg (2015). The first two explore whether boys and girls were equally successful in a certain Robotics program and if girls' and boys' interests and motivations for learning science increased together with a certain science program. Hallström, Elvstrand, and Hellberg (2015) on the other hand, investigated how girls and boys explored and learned technology during free play. The findings of Sullivan and Bers (2013) and Patrick, Mantzicopoulos, and Samarapungavan (2009) hardly showed any differences in the result between the girls' and the boys' learning of science, however Patrick et al. showed that the science program especially benefitted the girls' interests compared to another group of girls and boys who did not participate in the program. This can be compared with the results from Hallström, Elvstrand, and Hellberg (2015) focusing on free play, who instead found that the girls and boys in their study learned to approach and handle technology differently, confirming rather than challenging gender boundaries.

Theoretical foundation

As a theoretical foundation, this study makes use of a new materialist perspective and especially Karen Barad's theory of agential realism. New materialist perspectives 'stem from' post-humanist theory. Post-humanism, in turn, can be understood as an overall appellation for different perspectives which all have in common to question the human as universal/the centre and as a fixed defined category. Post-humanism and new materialism are not 'new' perspectives but rather re-workings and/or developments of other perspectives, such as postmodernism, social constructionism and poststructuralism. The 're-workings' have been developed through different researchers addressing the need of ways to highlight materiality as agential and to decentre the human (see for example Alaimo and Hekman 2008; Barad 2003; Haraway 1991; Latour 2005; Lenz Taguchi 2013). This study is informed by agential realism as this theory has its base in gender theory and explicitly focuses on how processes of knowing always are mutual and entangled with processes of becoming. This stance is seen as fruitful for exploring the research questions at hand.

Agential realism, intra-activity and material-discursive phenomena

In Karen Barad's theory of agential realism (and overall in new materialisms) nothing is ever stable and fixed in any essential way, but instead seen as always traversing and creating each other (materiality and discourse, humans and nonhumans, nature and culture,

matter and meaning and so on) (Barad 2003, 2007, 2014). That is, there are no pre-existing things, humans or identities. Instead, there are relations creating phenomena in intra-activity – such as, for example, humans, gender and knowledge (Barad 2007). Compared to the more commonly used interactivity, which refers to a meeting between two pre-existing agents or entities, intra-activity refers to the material-discursive relations in which what we think of as separate and pre-existing (such as humans or objects) are taking shape and acting (Barad 2007). This means that not only humans but also nonhuman matter is seen as agential, and as never settled, but always shifting (see Barad 2010). In this sense there are no humans, objects or discourses per se, acting or making things happen on their own. Instead, Barad speaks of material-discursive performative agents (materiality and discourse always traversing each other). This means that agency (and therefore action, intentions, choices, and so on) occurs intra-actively and depends on what is co-acting for the moment (Barad 2003). Agential realism not only has implications for how identity and matter are seen, but also of how space and time are seen. Instead of events happening in space and time in a linear way, in this perspective, events, time (past, present and future) and space are seen as iteratively done or unfolding in intra-activity, constantly being reconfigured. Space and time can in this way not be seen as separated why Barad (2010) speaks of spacetime, and spacetimematterings.

Analytical concepts to think with

Within an agential realist framework, gender is produced in line with Barad's notion of *post-humanist performativity* (Barad 2003, 2014). That is, as *material-discursive phenomena* always becoming and being iteratively reconfigured in entanglements with space and time (spacetime) and the becoming of spacetime (also see Juelskjaer 2013). This development of Butler's (1993) notion of performativity strengthens the focus on all kinds of matter, not only the human body and materiality connected to the body. In this way, gender is viewed as iterative doings, performed differently depending on what and who (children, scientific content, places, materials, discourses, and so on) are co-acting at the moment. Even though nothing 'stands still' but instead always is becoming, bodies, identities, actions, places/spaces, and so on can materialize by being repeatedly done/enacted over and over again, making us perceive persons, things, and spaces as pre-given in certain ways (Barad 2003, 2014; Butler 1993). However, since there is always intra-activity going on, there are always possibilities for other actions and becomings. Intra-actions are constraining, but not completely determining (Barad 2003). Together with Barad's theory (2010), identities always have a possibility to be performed differently given different circumstances (also see Butler 1993).

Understanding gender as mutual processes with (scientific) learning can be linked to Barad's concept *knowing-in-being* (Barad 2003, 2007). Barad brings in the entangled notion onto-epistemology, to illuminate that all processes of becoming are seen as mutual and simultaneous with processes of knowing. That is, processes of knowing occurs at the same time as children (humans) become as subjects and in these processes materials, things, places, discourses, and concepts are seen as co-creators.

To strengthen the focus in the analysis of how the children explored together with science, the notion of *scientific concepts as creative playmates* (de Freitas and Palmer

2016) is used. This means that scientific concepts in this study are not only treated as contents to learn about but also as agents to learn and play with and are as such seen as both co-creators of the children's explorations as well as becomings. Since gender theory (Butler 1993) 'informs' agential realism (Barad 2007), it gets possible to think of scientific phenomena as also taking part specifically in co-creating *gendered* becomings. That is, scientific phenomena can be seen as agents – together with discourse, materiality, and the children, and so on – taking part in co-creating the iterative doings in which gender gets constructed, within children's play and explorations.

Methodology and research context

Science and gender in the Swedish preschool and the preschool of the study

In 2010 the Swedish preschool curriculum's focus on children's learning (overall) was strengthened, as was the focus on science (and mathematics, and language) (National Agency of Education 2010). However, the Swedish preschool curriculum does not include specific learning goals. Instead, the curriculum formulates what the preschool should offer the children. Learning is described as strongly connected to children's play and explorations of their surroundings. Gender equality has been an explicit part of the Swedish preschool curriculum since it was launched in 1998 and in its current iteration, the curriculum states that the preschool should counteract gender stereotypical roles (National Agency of Education 2016). In spite of this, research shows that girls and boys often are given different opportunities (see for example Eidevald 2009). Two recently made quality review reports show that both gender and equality issues as well as science and technology are areas in need of development in Swedish preschools (Swedish School's Inspectorate 2016, 2017).

In the preschool of the study, the indoor environment was divided into a number of activity-areas that the children could choose from. The areas were arranged by the teachers in line with the content of the curricula. That is, in the different places the children could explore and develop knowledge concerning construction, aesthetics, language, letters, numbers, mathematical and scientific concepts, and so on and the indoor environment was set up in such a way that several knowledge areas could be explored simultaneously. As such, the children could explore emergent science in different ways in most of the spaces of the preschool. For example, there were different types of construction materials in almost every room, a projector for explorations of light and shadow in one room, pipes and tubes to explore sound and to move things with/in, paint and pens for experimentations with colours, glue and clay, books about animals and nature, sand, plastic animals, and so on. The teachers explained that they tried to arrange an environment consisting of 'unfinished' materials that the children could transform and be creative together with. Arranging this kind of 'unfinished' environment can, except from supporting learning, also be connected to the statement in the curricula about counteracting gender stereotypical roles (National Agency of Education 2016), why 'unfinished', 'gender neutral' environments consisting of materials that are not pre-given (pre-gendered), often are advocated in Swedish preschools.

Field study and data construction in preschool practice

The field study took place in a preschool outside a bigger city in Sweden, in a group of 25 children (11 girls, 14 boys) aged five years old, and three teachers. During the field study, participant observations, including video recordings and field notes, were made over a period of 5 months. On average the first author visited the preschool twice a week (visits lasting 2–6 h). In total the observations amounted to 155 h, out of which 12 h were video-recorded. During the field study, the observer moved around between the places where the children were. Sometimes activities that showed a potential for emergent science were sought out, at other times the observer sat down where some children were playing/exploring to see what evolved. Barad (2007) state that the researcher is always part of the phenomena they try to understand and that the observed 'object' cannot be separated from the agencies of observation (Barad 2010). In this sense the researcher cannot be considered the only agent deciding what to film or write, rather the data is co-created by the researcher(s), the research questions, the children, the preschool environment, the camera, the theoretical concepts, and scientific contents explored by the children, and so on.

The guardians to five of the children did not agree for their children to be filmed, therefore filming had to be adjusted to make sure that none of these children were included. The field-notes were guided by the research interest of the study, but a formalized observation guide was not used. The focus of the field study was the children together with the preschool environment. However, shorter, informal conversations with the teachers were also carried out. After each visit, the video sequences were transferred to an external disk and the field notes were directly transferred into word documents. In total, 40 computer written pages were constructed, consisting of 19,233 words (6302 for this article). Before the start of a video-recording, the children were always asked if it was okay to film what they were doing. They were also reminded that they could ask for the filming to stop at any time. If a child seemed uncomfortable with being filmed the camera was turned off or the child was reminded they could ask for the filming to stop. In this way, the children's consent was dealt with on a moment to moment basis. Before the field study, a letter was sent to children and guardians with information about the study. During the first visit at the preschool and again in the middle of the field study, the first author also had a conversation with the whole child group, gathered during circle/carpet time, about the study and the purpose of the visits and observations. The children were then encouraged to ask any questions they had about the first author or the study. Teachers and guardians also received more detailed information about, e.g. the aim of the study and methods for the data collection. The guardians were also informed about the possibility to withdraw their children from the study at any time and about the handling of the data, before they were asked to sign a consent form. The study adheres to the Swedish Research Council's principles for research ethics (Swedish Research Council 2011) and has been approved by the regional board for research ethics. The description of the preschool is purposefully vague in order to assure confidentiality.

Diffraction methodology and diffractive readings

In the analysis, Barad's diffractive methodology and diffractive readings (Barad 2007, 2014) are used. Diffractive analyses are about looking for differences within phenomena,

focusing on encounters, co-actings, and entanglements, and what these differences might do (see Barad 2007, 2014; Hultman and Lenz Taguchi 2010). Diffractive readings imply reading different insights (concepts, materials, parts of data, and so on) through one another (Barad 2003). Data can in this perspective be seen as ‘pieces’ which have been ‘cut out’ from the world’s multiplicity – that is, data construction here means cutting-together-apart (see Barad 2014). However, the researcher is not seen as the only agent in the making of cuts, rather these are seen as enacted intra-actively (together with the researcher, theoretical concepts, technologies, discourses, the children, and so on). The cuts separate some things from their entanglements and intra-activities, but in the same time, new entanglements are iteratively created as the cuts intra-act with the concepts, researcher, different technologies (computer, pens, papers), and so on, during the analysis. Both data and theoretical concepts are here seen as agential and co-creating the analysis, as something the researcher read, think, and write together with (Barad 2007, 2014; Palmer 2010; Taylor 2013).

Diffractive readings together with the selected data

The analytical process commenced by constructing a list of the content in each video sequence to create an over-view of the material. Then both the video sequences and field notes were sorted according to the place in the preschool where they were constructed. Another list was made concerning where different children had chosen to be on different days/different times during a day, as they were indoors. This list showed that the three places where the children most often spend time were the ‘drawing table’, ‘the construction room’, and ‘the playroom’. It was most common for girls to choose the drawing table and for boys to choose the construction room. The playroom, which was intended to be a place where the children could engage in creative play/role play with various ‘unfinished’ materials, was chosen by both. Since division by gender was a daily pattern during the whole field study at the drawing table and the construction room, the data from these two places were chosen as a point of departure for this article. The construction room and its materials could seem like a more ‘obvious’ choice when researching emergent science in preschool than the drawing table. However, in order to be able to detect ‘other ways’ of becoming scientific in preschool and/or how gendering co-create different opportunities for different children it is important to not only engage in places and materials commonly thought of as ‘scientific’, hence, the drawing table was also included. The data from these two places totally consisted of three hours of video recordings and eight computer written pages of field notes. All of this has been worked with during the analysis. To be able to look close and carefully on details, numerous screenshots/agential cuts were taken out from the video sequences. The video sequences are agential cuts constructed during the field study, that is, shorter events from certain angles ‘cut out’ from their entanglements with larger events, other places, agents, and so on. As such these ‘cut out events’ (video sequences) could during the analysis be part of new entanglements, with for example the theoretical concepts. By again ‘cutting the video sequences apart’ into screenshots – these could also in turn entangle in various ways, for example with each other as many screenshots could be placed next to each other, with the researchers, theoretical concepts, and so on. Accordingly, during the work with the analysis, new/more agential cuts were constructed along the way co-

creating the analysis in different ways. As many of the agential cuts were worked with at the same time, there were certain doings which stood out as occurring daily in the data. These 'daily doings' create a certain 'overall' narrative of both places, which make the doings and places occur as certain phenomena being iteratively constructed. When the agential cuts were worked with one by one, they initiated other thoughts and focus on certain details, for example, the children's close relations with different types of materials and certain scientific phenomena. For instance, the various screenshots from the construction room consisting of different bodily postures, made us focus on how the becomings of the boys' bodies and movements in this place were entangled with their explorations of emergent science. Details were for example highlighted concerning how the boy's entanglements with the phenomena of rotation made their bodies lie down, stretch out and take up a lot of space. When working with the video sequences as films (not screenshots) effects of intra-actions such as motions, sounds, discussions, participation, and explorations were focused. Some of these were written down as short texts and then added next to the screenshots, and 'cut out' text from the field notes was also added. In this sense, the screenshots, together with different kinds of text, created new agential cuts, which in turn co-created new thoughts and made other details stand out. For example, when text consisting of the children's verbal expressions were added next to the screenshots this made it possible to detect and focus on specific 'things' in the photos, such as details concerning the importance of colour in the construction room as well as expressions of gender discourse in both places. As such it was possible to create a kind of mapping over both places which consisted of movements and sound (video), as well as frozen details (screenshots) and text. During the readings, different agents in the data (bodies, things, materials, talk, discourses, emergent science as content and method, scientific phenomena) were followed and it was explored what these did with the researchers thinking together with the theoretical concepts – also treated as agents co-creating thoughts. As one example, when reading de Freitas and Palmer (2016) thought of scientific phenomena as creative playmates together with agential cuts from the drawing table it became possible to think differently concerning the girls' drawings of rainbows.

Findings

We start to describe the overall phenomena of each place below. After this, we get into the differences within these phenomena which came to the fore as we switched back and forth between intra-acting with the theoretical concepts and the agential cuts one by one and the theoretical concepts together with many different agential cuts at a time.

The 'Overall' phenomena of the drawing table

The drawing table was daily chosen (and occupied) by many of the girls. Activities which occurred daily were to draw and colour different kinds of shapes and writing the names of their friends or pop idols. Often, drawing templates made of plastic or printed out on paper were used. Common shapes to colour were hearts, pumpkins, cakes, and rainbows and a common way to colour were by 'rainbow patterns' or different colour blocks. Another daily doing were to make things (drawings, paper constructions or letters) to

take home or to give away. The girls also daily asked each other: 'Who is that for?' 'Can I have that one?' 'Who wants this?' 'Do you think NN will like this one?' Except from this kind of questions the girls daily praised each other's drawings by expressions like: 'Oh, your (drawing) is so pretty!' 'Is mine pretty?' 'Yours is cuter than mine!' 'No yours is really cute!' This meant that for a child to 'choose' this place they had to be able to entangle or identify with these (feminine) actions, focused on aesthetic qualities and caring. Since science has a tradition of being a masculine coded discipline (Harding 1986) all these daily repeated 'feminine signs or qualities' at first made it difficult to detect explorations of emergent science at this place. Our first interpretation focused more on the girls and their entanglements with the 'feminine' discourses than the materials in their hands.

Differences within the phenomena of the drawing table – exploring and becoming together with colour, shapes and rainbows

When the diffractive reading proceeded the concepts of intra-action and post-humanist performativity (Barad 2003, 2007) opened up for understanding the girls as entangled with the various agentic materials, which made us detect how the girls, while making things to give away and complementing each other's drawings, also were exploring emergent science. All the time their hands were linked to pens or scissors, moving back and forth over the papers while colouring different shapes, or following the contour of a shape while cutting or folding. Numerous explorations were nonverbally going on at this place the whole spring, as in this example: A girl first folded a sheet of paper one time and then she, together with scissors, cut out tiny symmetrical heart-shaped pieces. Before giving these away to other girls at the table she decorated them by drawing together with different colours. By folding one of the hearts she could also cut out a minimal hole in the middle of it. Then she gave this heart to another girl who, before she in turn gave it to a third girl, also decorated it with colour. The third girl placed the tiny heart in front of her eye and detected that it was possible to see through the minimal whole in the heart. Then, together with glue, she made the heart stick onto a paper in front of her. This example, as many other situations in this place, included construction, techniques of cutting and folding, colouring as well as making surfaces 'sticking' together, and explorations of perception and light transmission (through the minimal hole).

When thinking together with de Freitas and Palmer (2016) thought of scientific phenomena as creative playmates, more aspects of emergent science could come to the fore. In the girls' entanglements with the pens, the colours – as optical phenomenon – worked as important 'playmates'. Colours were present in almost all intra-activities. One of the most common discussions concerned which of the pens that held 'the best' blue, 'the best' purple, orange, and so on. In this sense, the girls were testing and categorizing different nuances and intensities in each colour. As already mentioned, rainbows were common motives. The girls were drawing and colouring together with and inspired by the look of this certain optical phenomena, over and over again. Since the girls did not talk about their rainbows as optical phenomena, in the 'overall narrative' of the drawing table, these drawings were at first taken for 'pretty motives' and expressions of femininity or gender discourse rather than events bearing scientific potential. However, when seeing these drawings as material-discursive phenomena and not only discursive phenomena,

the explorations of emergent science could be highlighted – without ‘leaving the discourses behind’.

It was clear that the girls daily were doing emergent science together with materials and discourses not commonly viewed as ‘scientific’. When also thinking with post-humanist performativity and knowing-in-being (Barad 2003, 2014) it gets possible to see how these iterative intra-actions also created the girls’ identities – that is, as focused, ‘still sitting’ makers/constructors of (pretty) ‘things’ to give away. The chairs at the drawing table iteratively worked as ‘things’ holding the girls’ bodies still and in place and made them keep the materials on the table (instead of for example placing the pens, papers, and themselves on the floor). In this sense, their bodies iteratively got ‘disciplined to stay in place’ together with the table and the chairs, rather than encouraged to take up a lot of space and move around. Since spaces too always are intra-actively constructed (Barad 2010), mutually with the girls’ explorations and becomings, the drawing table was also iteratively becoming during the whole spring as a place/space for certain actions, explorations, and identities – seeming like a pre-existing place which the children could ‘choose’. Thus, the colours, papers, and rainbows both co-created the girls, their explorations, and the space itself.

The ‘Overall’ phenomena of the construction room

The construction room was instead chosen (and occupied) by many of the boys. Activities which stood out as daily doings were to build Beyblades and to have spinning competitions, mostly together with a material called plus-plus (small pieces looking like two plusses sticking together). Beyblades are toys which you spin and compete with, which originally come from a Japanese anime. Due to these Beyblades, the daily doings in this room consisted of construction and rotation. In contrast to the drawing table, the explorations of emergent science were more obvious here and rotation was easily highlighted as a creative playmate (de Freitas and Palmer 2016) in this place during the whole spring. Moreover, together with the thought of action and agency as occurring in *material-discursive* entanglements (Barad 2003), we could approach the materials, phenomena, and discourses as traversing each other. The play with Beyblades can (just as science), be seen as entangled with discourses and qualities often connected to masculinity such as competition, speed, winning, and construction. The boys often told each other how fast their Beyblade was and wanted the other ones to look at it. They often expressed things like: ‘Look at mine!’ ‘Mine is really fast!’ ‘Mine is going to win!’ ‘It is super easy to build (a Beyblade).’ ‘This was my best/worst (spin).’ ‘How can I make this (Beyblade) cooler?’ And so on. To ‘choose’ this room one needed to entangle with this ‘Beyblading’ and identify with it. In one rare situation when there were girls in the room, one of them stated: ‘I know how to build Beyblades, but I won’t do it!’ However, as we continued the diffractive analysis, this ‘overall’ picture of the doings in/of this place was nuanced.

Differences within the phenomena of the construction room – exploring and becoming together with popular culture, rotation and colour

The boys spent much time constructing their Beyblades. After building one, they tested its spinning ability, rebuilt it, and tested it again. In this sense playing with the Beyblades

included scientific methods such as problem-solving, trying new ideas, improving the design, and so on. When, for example, the boys tried to put extra pieces on their Beyblades and then had to figure out its balance.

Since there daily were Beyblade competitions going on in this place, at first, the most important (nonhuman) agents in here seemed to be the Beyblades, rotation, and the discourses about competing and winning. However, various important agents were highlighted which co-created this 'Beyblading'. When more closely engaging in details, we noticed how, not only rotation, but also optics worked as a creative playmate and as an important agent. As the Beyblades were rotating, the boys experienced the colours of their Beyblades differently. The effect of this was that during construction, not only the shape, balance, and strength of the materials was of importance, but also the colours of the plus-plus pieces. The phenomena of optics made the boys spend much time on choosing and sorting colours in different combinations on their Beyblades. At one time a boy showed the first author that he managed to turn the colours on his rotating Beyblade 'into gold'.

On one of the walls, a wardrobe was attached around 20 cm above the floor, which made the space underneath it dark. This space also became an important agent by encouraging the boys to lie down on the floor and explore if their rotating Beyblades, constructed by neon-coloured plus-plus pieces, would glow in the dark. Together with the various colours and the wardrobe, the boys' explorations could include more than speed and spinning duration. This also somewhat opened up for other identities since the inquiries together with the dark space and colours became less determined by the discourses of winning. However, it was still important that the Beyblades 'looked cool'.

Thinking with knowing-in-being and post-humanist performativity (Barad 2003, 2007), in the intra-activities in this room, the boys iteratively became as focused, concentrated and still sitting while constructing, but also as focused, concentrated and movable while rotating the Beyblades. Except from lying on the floor, the rotating Beyblades forced the boys to follow them by walking on their knees, crawling, stretching out their arms, and so on. In this sense the boys and their bodies, together with rotation, optics, and discourses about speed and winning, iteratively got encouraged to take up a lot of space, both physically and sound wise. In the same time, the various colours on the plus-plus pieces also encouraged the boys to sit closely together while carefully choosing colour combinations and observing the choices of each other. Following the thought of nonhuman matter as also iteratively becoming (Barad 2014) – in the intra-activities in this room (and of this room) the chairs sometimes became as 'things' holding bodies next to the table and sometimes the table and chairs became as platforms for spinning Beyblades at different heights. That is – rotation and optics were, together with discourses connected to winning and competing, co-creators of the space, children, and 'things' in it. Just as the drawing table, the construction room was also iteratively becoming during the whole spring as a place/space for certain actions, explorations, and identities – seeming like a pre-existing place which the children could 'choose'.

Conclusions and implications for practice

The findings show how different explorations of emergent science were going on both at the drawing table and in the construction room. However, this occurred in slightly

different ways, and as such the children constituted different identities together with the two places. The girls and their bodies iteratively got 'disciplined to stay in place' by the chairs, colours, papers, and discourses at the drawing table. The boys and their bodies were instead iteratively encouraged, by the materials, discourses, and the phenomena of rotation in the construction room, to take up a lot of space, both physically and sound-wise, as well as encouraged to sit closely and 'calmly' together. Following Hirdman (1990) this can be understood as the children participating in gendered power-relations, in that such power relations are linked to the ability to occupy space. To participate in the doings of a certain place also involved taking part in the constitution of certain identities and taking stand from others. In this way, not only the children but also the actual places were iteratively constructed in similar ways day by day – making them appear as pre-existing places. The 'fixed appearances' of the two places made it difficult for the children to traverse the gender stereotypical roles which daily were reconstructed. In turn, this also affected how girls and boys could explore emergent science. To repeatedly explore the same phenomena many times, as the children did in both places, can be seen as part of the scientific method and is also an important element in children's learning (Eshach and Fried 2005). But repetitive acts are also parts of gender and identity construction (Barad 2014; Butler 1993). Since the children were spending much time in the same places there is a risk that – over time – both the doings of emergent science and the doings of gender would become narrow for the individual child. As such, teachers both need to be able to support children's repetitive doings if these seem to be an important part of their explorations and desire to learn – and in the same time, teachers need to challenge the children when their repetitive doings seem to be repetitions in performing gender in narrowing ways. Since the girls identities iteratively were made intelligible in close relations, not only with the drawing table but also with each other, and the boys identities iteratively were made intelligible in close relations, not only with the construction room but also with each other, for one of these children to 'suddenly' choose to join the explorations in the 'other place' was not easily done. In some occasions, some of the boys did sit down at the drawing table, with the aim to draw, however, when this happened they did not engage in the same motives or the same conversations as the girls. At a few occasions also some of the girls went into the construction room. However, while doing so, some of them expressed that they didn't know how to build a Beyblade, or that: 'I know how to build a Beyblade, but I won't do it!' This shows that identities, explorations and places, which are repeatedly constructed in similar ways day by day, are not easy for 'an outsider' to join.

However, when being attentive to the children's doings in the two places, not only differences but also common interests and explorations came to the fore. Here there were potential for the teachers to highlight these similarities to the children and assist them in intra-acting with a range of optical phenomena as creative playmates (de Freitas and Palmer 2016) and in this way broadening their explorations and becomings. For example, there were potential for the teachers to make use of the explorations at the two places and turn these into a shared scientific project with a focus on colour, rainbows, optics, and light. Hence, a shared scientific focus could have encouraged and challenged the children to engage in explorations they would not have 'chosen' in the first place. This could perhaps have made the children's identities as well as the drawing table and the construction room to become 'less fixed'. However, teachers need to be

aware that keeping children's explorations and becomings 'open' or less 'fixed' is an ongoing process. This means that also within a shared science project, teachers actively and iteratively need to consider and re-consider the possibilities and constraints for individual children to explore and become. To do so, it is important that teachers make sure that the shared scientific focus is not to 'narrow' or 'fixed', but allows explorations with various materials, in various ways, and places. Furthermore, even though girls and boys explore together within the same activity or play, this does not automatically lead to a situation that is necessarily more equal (see Günther-Hanssen 2018), why teachers' gender awareness in combination with subject-specific knowledge plays an important role (Gullberg et al. 2018), in each situation, moment by moment. The new materialist perspective, taking both gender, materiality, and discourse into account, made it possible to highlight the numerous small *non-verbal* explorations which constantly were going on between the children, materials, and scientific phenomena in both places. If the focus had been limited to children's co-actings with materials it is likely that the gaze had been drawn exclusively to places and materials which could be considered to have 'easily detected scientific potentials' (like the construction room). By thinking with Barad (2003, 2007) and 'everything' as always *material-discursive*, and knowing as *always* entangled with being, it instead became possible to detect how science can be done in ways and together with agents not commonly thought of as 'scientific'. For example, how doing science can be mutual with processes of 'doing girl' and that emergent science can be explored together with unexpected places, materials, and discourses, such as a drawing table, hearts, and feminine discourses or by sitting closely together and observing and imitating each other's choices of colour combinations. As such, this study contributes to a growing body of research that problematizes what science in preschool can be (cf. Andersson and Gullberg 2014; Siraj-Blatchford 2001; Siry 2013; de Freitas and Palmer 2016). This is particularly pertinent in relation to how school science often is perceived as a fixed body of knowledge (Carlone 2004). This can be considered a dual process, where the scientific potential is brought to the fore in unexpected places but also where the scope of what can be seen as science is broadened. Since science has strong masculine connotations (cf. Harding 1986) – when focusing on *child-material* relations and not on *child-material-discursive* relations – there is a risk that explorations of emergent science entangled with feminine discourses might be hard to notice – especially for adults. When it comes to places like the construction room, which just as science and technology, were traversed by masculine discourses, the explorations of emergent science were easy to detect. In this sense, there is instead a risk that these 'easily detected' explorations of emergent science gets treated as 'neutral' processes in preschool and that the masculine discourses therefore gets neutralized/overlooked. As such, considering places as materially-discursively produced and always entangled in broader socio-historic discourses highlights how teachers cannot rely on any environment, activity, choice or subject content to be (gender) neutral. The findings of this study show the importance for further studies to use a gender perspective on science education already at the preschool level and not only in relation to older school pupils/students which have been more common. The findings also point at the need for further research to, when trying to understand the various ways in which young children explore and become together with science, children's close entanglements with scientific phenomena, materiality, and norms and discourse need to be taken into account. Otherwise, there is a risk that some children, some ways and

some places will be overlooked and perhaps even excluded from the understandings of what emergent science can be, how it can be done, and by whom.

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