



A swing and a child: how scientific phenomena can come to matter for preschool children's emergent science identities

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Abstract

The focus of this study is the co-actings of a 5-year-old girl, a swing, and physical phenomena. The study explores how the swing and physical phenomena worked as co-creators of the girl's scientific explorations as well as her bodily capacities and identity construction. Empirically, the study makes use of a video sequence generated during a field study in a Swedish preschool with 5-year-old children. The field study focused on the children's play and explorations together with the preschool environment, during activities not specifically guided by teachers. To conceptualize children's emergent scientific learning as mutual with their identity construction and as being co-created together with nonhuman agents, the study combines perspectives from new materialism, emergent science, physics, and gender theory. As a theoretical and methodological foundation, a new materialist perspective drawing on Karen Barad's (Meeting the universe halfway. Quantum physics of the entanglement of matter and meaning, Duke University Press, London, 2007) theory of agential realism and diffractive methodology were used, as well as Elizabeth de Freitas and Anna Palmer's (Cult Stud Sci Educ 11(4):1201–1222, 2016. <https://doi.org/10.1007/s11422-014-9652-6>) notion concerning how scientific concepts can work as creative playmates in children's explorations. The findings show how the girl, together with the swing, could experience and explore various physical phenomena as well as, extend her bodily capacities and become brave and strong. As such, new materialism shows how scientific phenomena can create affordances for an individual's becomings as scientific as well as how "becoming scientific" can be understood. At the same time, the findings also indicate the importance of teachers not assuming that scientific phenomena are automatically part of children's play or can be experienced by all children all the time. The explored situation was rare. On most occasions, the girl did not get the same kind of experiences with the swing because of gender norms. I argue that norms and discourses connected to science and gender are not things that "come with" older children or are only introduced by adults. These are instead already in the making and re-making within children's co-actings with the material-discursive environment in preschool. It is therefore important that teachers engage in children's embodied play with scientific phenomena, with the aim to empower the children, their bodies, capacities and (science) identities.

Keywords Emergent science · Gender · New materialism · Science identity · Embodiment

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Sammanfattning

Den här studien undersöker samhandlandet mellan en femårig flicka, en gunga och olika fysikaliska fenomen. Det som studeras är hur gungan och de fysikaliska fenomenen fungerade som medskapare av såväl flickans naturvetenskapliga utforskande som hennes identitet. Empirin består av en videosekvens genererad under en fältstudie i en svensk förskola i en grupp med femåriga barn. Fokus för fältstudien var barnens utforskande och lek tillsammans med förskolans lärmiljöer under aktiviteter utan ζ ledning av pedagoger. För att undersöka barns begynnande naturvetenskapliga lärande i samspel med deras identitetsskapande, kombineras perspektiv från nymaterialism, begynnande naturvetenskap (emergent science), en konceptuell förståelse av fysik, samt genusteori. Studiens teoretiska och metodologiska utgångspunkter utgörs av Karen Barads (Meeting the universe halfway. Quantum physics of the entanglement of matter and meaning, Duke University Press, London, 2007) teori agentisk realism och hennes diffraktiva metodologi, samt de Freitas och Palmers (Cult Stud Sci Educ 11(4):1201–1222, 2016. <https://doi.org/10.1007/s11422-014-9652-6>) idé om hur naturvetenskapliga fenomen kan fungera som kreativa lekkamrater i barns lek. Genom en konceptuell förståelse av fysik kunde flertalet fysikaliska fenomen framträda som lekkamrater (de Freitas och Palmer 2016) i flickans utforskande tillsammans med gungan. Tillsammans med Barads teori (2007) blev det möjligt att se hur de fysikaliska fenomenen inte fanns där som ”förexisterande” lärandeinhåll utan hur de, genom flickans upprepade kroppsliga samhandlande med gungan, kunde ge sig till känna. I situationen blev acceleration, hastighet och kraft inte enbart viktiga lekkamrater i hennes naturvetenskapliga utforskande (de Freitas och Palmer 2016) utan även i hennes identitetskonstruktion. I samhandlande med de fysikaliska fenomenen kunde flickan utöka sin kroppsliga kapacitet och bli till som stark och modig. Resultaten visar därmed hur naturvetenskapliga fenomen kan delta i ett barns (en individs) konstruerande av en naturvetenskaplig identitet samt även av identitet i ett bredare perspektiv. Att bli till som naturvetenskaplig är därmed inte något man kan göra på egen hand utan något man kan bli i sammanflätningar och samhandlande med omvärlden. För att pedagoger ska kunna upptäcka hur barn på många olika sätt utforskar, leker och blir till, tillsammans med naturvetenskapliga fenomen, blir kunskaper om naturvetenskapliga begrepp och fenomen i första hand ett verktyg för dem och i andra hand för barnen. Tillsammans med sådana kunskaper kan pedagoger öppna upp för multipla förståelser för hur det är möjligt för barn i förskolan att påbörja skapandet av en begynnande naturvetenskaplig identitet. Samtidigt visar resultaten att pedagoger inte kan ta för givet att naturvetenskapliga fenomen automatiskt ”ger sig till känna” på samma sätt för alla barn. På grund av könande processer, behöver pedagoger vara uppmärksamma på när, hur och tillsammans med vad som fenomenen gör sig begripliga för olika barn. Situationen i videosekvensen var ovanlig och på daglig basis var möjligheterna få för enskilda barn att utforska och bli till på många olika sätt. Om pedagoger inte tar könande processer i den naturvetenskapliga undervisningen i beaktande finns en risk att vissa barn—redan i förskolan—uppfattas som ”mer naturvetenskapliga” än andra, på samma sätt som studier visar sker i relation till äldre elever och studenter (Carlone in J Res Sci Teach 41(4):392–414, 2004. <https://doi.org/10.1002/tea.20006>).

A swing in a preschool yard in Sweden. Like most days, the swing is full of children, sitting and lying on it. Two children stand in the gravel on opposite sides of the large swing, taking turns pushing it. There are no teachers in the swing area, and the children doing the pushing use their whole bodies to increase the swing's speed. The children sitting and lying on the swing cheer together: “higher, higher”, enjoying the feeling of acceleration

that affects their bodies. Suddenly a child jumps from the edge of the swing. Another child in the middle of the swing sees a chance and directly moves to get the spot that the child who jumped off left behind. A few children also sit on the fence surrounding the swing set area, queuing for their turn. Later, as the pushing and swinging have stopped for a moment, some children remain on the swing, sitting and talking or trying to climb its bars all the way up to the frame from which the swing hangs. A boy is climbing, and some of the other children impressively shout: “Look at NN!” Emily, a girl who has been watching the climbing, also wants to try. But first she has to occupy one of the two spots by the bars. Ben, a boy who often climbs the bars, is not willing to give the spot away. A struggle starts between their bodies, and a discussion in a slightly irritated tone also emerges. Emily tries to start climbing while also using her body to block Ben and keep him from taking over the spot. Finally, Emily gets to climb the bars without being disturbed for a few minutes. She climbs up and leans her head backwards, towards the ground, in a way similar to what some of the boys just did a moment ago. Then she shouts: “This is so easy, this is so easy!!” However, none of the other children looks up or gives her any attention. Another day in the same preschool yard. The usually crowded swing is suddenly empty of children. Emily enters the swing set area. An opportunity emerges for her to play and explore undisturbed with the swing and various physical phenomena. Standing on the ground, she starts to push the swing higher and higher. At the same time, she happily states that she is going to jump from it.

To be continued...

In Sweden, preschool and school yards often contain one or more swings, and it is common for children to stand in a line waiting for their turn. Swings are, and have long been, popular “things” to play with. In fact, they may be the most familiar pendulums in the world (Pendrill and Williams 2005). One reason swings are so popular for children, could be due to the thrilling embodied sensations and forces one experience while swinging. In this study I make use of these thrilling embodied sensations and forces when studying a video sequence—when Emily, the girl in the introduction above, played alone, as the only human agent with the swing and various physical phenomena. The aim of the study is to explore a child’s engagement with scientific phenomena; however, not only how these phenomena can come to matter for children’s explorations and learning, but also for their capacities and identity construction. As such, the study adds to the body of contemporary studies within early year’s science that highlight science learning and processes of “becoming scientific” as something that gets created in children’s close relations with the (material-discursive) preschool environment (Haus 2018), and in this sense also to how processes of “becoming scientific” can be understood in new ways. In these studies, scientific phenomena are seen not only as content children learn *about*, but also as playmates that children learn and become *together with* (de Freitas and Palmer 2016). To further our knowledge about how “emergent science identities” can be constructed in human–non-human relations in preschool, two research questions have been formulated:

- How do a swing and scientific phenomena co-create Emily’s agency, explorations, and becomings?
- How do scientific phenomena take part in the Emily’s identity construction?

Before I present how different studies have engaged in preschool children’s identity construction in relation to/with science, I will introduce the theoretical framework used in the study.

Theoretical framework

In the study, learning is approached as a broader phenomenon than the acquisition of knowledge and/or certain skills. Accordingly, learning is enmeshed with other processes, such as socialization, identity formation, and subjectification (Biesta 2009). To conceptualize emergent scientific learning as mutual with identity construction and as co-created together with non-human agents (scientific content and discourse included), a new materialist perspective and especially Barad's (2007) theory of agential realism is used. New materialism is a posthumanist theory. Posthumanism disagrees with the notion that humans are superior and are the only entities with agency. New materialism assumes matter is agentic, co-creating agency, identities, and knowledge, together with humans (Alaimo and Hekman 2008).

Below, I describe Barad's theory of agential realism and its implications for knowledge and identity construction. The analytical concepts, from agential realism and elsewhere (de Freitas and Palmer 2016), that have been of special importance to the analysis are also explained.

Knowing-in-being in human–non-human relations

Physicist and gender theorist Barad (2007) argue that nothing is ever stable and fixed in any essential way. Everything should instead be seen as always traversing and creating each other (materiality and discourse, humans and non-humans, nature and culture, matter and meaning, and so on). This has implications for how knowledge production and learning are understood. Barad (2003) states that processes of knowing are always mutual and simultaneous with processes of becoming. That is, processes of knowing occur at the same time as children (humans) become as (gendered) subjects. In this sense, learning becomes an ontological question as much as an epistemological one. This is expressed by the concept of *knowing-in-being* (Barad 2007). In these processes, humans and non-humans—such as materials, things, places, discourses, and scientific phenomena—are seen as agents and co-creators (Barad 2010). This means that the construction of knowledge, identities, and learning (in preschool) are seen as occurring in entanglements of humans (children, teachers) and non-humans (things, materiality) and that matter—such as the preschool environment, bodies, things, and scientific phenomena—are inseparable from meaning, knowledge, and discourse (Barad 2007). This stance has implications for how learning scientific content is approached in this study. Instead of seeing scientific phenomena as something pre-existing that humans can learn *about*, agential realism instead turns scientific phenomena into something we learn *together with* (and about) as well as *become* together with. In order to apply this stance in relation to preschool science, some other perspectives and notions have been used together with agential realism, as explained below.

Knowing-in-being with scientific phenomena in preschool

In order to make Barad's (2007) notion of knowing-in-being useful for preschool and preschool science, the present study also takes its point of departure in the notion of "emergent science" (Siraj-Blatchford 2001). The concept of emergent science was developed by John Siraj-Blatchford (2001), who aimed to shift the focus on learning science in preschool

from individual children's conceptual understanding of a predetermined teaching content to science as a social practice, something already being explored by the children daily during play. A new materialist perspective expands emergent science's social practice to a *material-discursive* practice which includes non-human agencies. To focus on how the scientific phenomena in the data worked as agents in the girl's ongoing play, de Freitas and Palmer's (2016, p. 1220) notion of how "scientific concepts can work as *creative playmates in children's play and explorations*" was also used. Finally, to highlight Emily's bodily experiences with different physical phenomena and how these co-created her knowing-in-being, I used a conceptual approach to physics (Hewitt, Suchocki and Hewitt 2008). This helped me to better understand how various physical phenomena affected both Emily's body and the swing.

Below I will discuss the "being" part of knowing-in-being, and how identity construction in the present study is understood with an agential realist perspective.

(Gendered) identity construction as posthumanist performativity

To explore children's explorations and learning as entangled with (gendered) becoming and identity construction, I use Barad's (2003) notion of *posthumanist performativity*. This notion is developed from Judith Butler's (1993) concept of *gender performativity*. Butler describes how gender and identity can be understood as a doing or act, performed through daily repetitive actions co-created by (gender) norms; thus, making our bodies and identities seem fixed and pre-existing. Through these doings, we become as women and men, girls and boys according to gender norms (Butler 1993). These processes generate power relations, which create different possibilities for people to act. In Barad's reworking of the concept, which she calls *posthumanist performativity*, all kinds of matter are included and understood as co-creators of identity construction (Barad 2003). That is, also matter and other non-human agents which are commonly considered as mundane or gender neutral. This means that, for example, the scientific phenomena in the data also can be seen as agents in the Emily's identity construction. Here, gender and identity are understood as being material-discursively constructed, or as *material-discursive phenomena* that are always becoming and being iteratively reconfigured in *intra-activity* (Barad 2003). Compared to the more commonly used term *interactivity*, which refers to an encounter between two pre-existing agents or entities, *intra-activity* refers to the material-discursive entanglements (materiality and discourse always traversing each other) in which the things we think of as separate and pre-existing (such as humans or objects) are taking shape and *intra-acting* (Barad 2007). Within *intra-activity*, there are no humans, bodies, objects or discourses per se, acting or making things happen on their own, but that agency is created through *intra-activity* (Barad 2003). In *interactivity*, the child is a "pre-existing agent", exploring and interacting with various things in the preschool, and that agency as such "belongs" to the child, while in *intra-activity*, the child is considered to *become* as an agent in different ways in each encounter—with different rooms, materials, other children, teachers, and norms. The same child can become fast and brave in *intra-action* with one place, certain clothes, and norms, but cautious and slow in other *intra-activities* in another place, other clothes, and norms (Günther-Hanssen 2018). This means that the child's identity and agency are dependent on what *intra-actions* the child is part of for the moment and in what ways (Lenz Taguchi 2010). As such, in line with *posthumanist performativity*, identity and/or gender is understood as being iteratively performed through daily acts, in different ways

depending on what and who (children, scientific phenomena, places, materials, discourses, etc.) are co-acting at the moment. Like Butler (1993), Barad (2003) uses the concept of *materializations* and explains how bodies, identities, actions, and spaces can *materialize* by being repeatedly enacted, making us perceive ourselves, other persons, things, and spaces as pre-given in certain ways (Barad 2014). However, identities always have a possibility to be performed differently in different circumstances (Butler 1993).

I will next discuss previous research on science identities or with younger children where researchers use the phrase “become scientific”.

Empirical explorations of children, materiality, and science identities

Within sociocultural studies, researchers problematize the image of science and young children. Many of these studies are influenced by the notion of emergent science (Siraj-Blatchford 2001). Instead of treating young children as less knowing or as misunderstanding science, these studies frame children as competent agents in their own science learning, who co-create preschool science (Caiman and Lundegård 2018) and how it can be done (Larsson 2013). In these studies, children are described as problem-solvers (Eshach and Fried 2005), as formulators of (scientific) ideas and theories (Conezio and French 2002), and as constructors of new knowledge (Siry 2013). For example, Susanne Klaar and Johan Öhman (2012) show how the youngest children in preschool can become agents in their scientific meaning-making through practical and physical explorations.

Materiality and scientific phenomena as co-creating science identities in preschool

Studies by Haim Eshach and Michael Fried (2005) and Tsunghui Tu (2006) highlight the important role that an environment rich in science equipment and materials contributes to children’s scientific learning and for their ability to become scientific. Also Teresa Cremin, Esme Glauert, Anna Craft, Ashley Compton, and Fani Stylianidou (2015) see exploratory contexts and opportunities to explore diverse materials and resources as crucial for children to make inquiries and become what they call “creative little scientists”. Many studies have stressed the significance of the materials in preschool; however, these are often seen as tools that the children (or teachers) can *use*. In the studies using new materialist perspectives, materiality/non-humans are seen as *agents* that children become scientific *together with*. In Sofie Areljung’s (2019) study, there are various examples in which children learn and become scientific in relations with non-human matter. One situation presented includes a number of preschool children and a wooden board placed over a ditch. Due to the slipperiness of the board, the children had to adjust their bodies by crouching down and walking with small, slow steps as they crossed the board. As such, the height and slipperiness of the board co-created the properties of the children’s bodies. Jana Maria Haus and Christina Siry (2019) underline the opportunities created when materials are treated as active agents and science learning as human–non-human relations. The conclusions made are similar to those drawn by Areljung (2019) and point at the importance of open-ended explorations between materials and children to support young children’s agency and (scientific) becomings.

Other studies using new materialist perspectives also engage with the agencies of the scientific content. In these studies, scientific phenomena and concepts are treated as agentive rather than pre-existing abstractions (Areljung 2018) and as creative playmates in children’s activities and learning (de Freitas and Palmer 2016). Various examples are given concerning

how different scientific phenomena can co-create not only children's explorations, but also their becomings. de Freitas and Palmer (2016) show how two children, building towers together with plastic beakers, became bodily and emotionally entangled with the concept of force. The children experienced the phenomena of gravity because the beakers kept falling down. The learning event caused the children to move their bodies in certain ways, choreographed by the falling beakers, and to express different feelings, such as excitement and joy. Jana Maria Haus (2018), inspired by de Freitas and Palmer (2016), showed how the phenomena of gravity, lift, drag, and thrust co-created how a boy moved, explored, and became, as he played with a sheet of paper. Through the event, the boy became a folder, maker and player and the paper became a plane. Haus relates these becomings to becoming scientific. She explains that concepts can be understood as material (rather than abstract) through children's embodied play and entanglements with them. Areljung (2018) provides examples of how children can feel various scientific phenomena *in* their bodies as they play, for instance force and acceleration when rolling down a hill. She suggests that one way to highlight children's embodied entanglements with scientific phenomena is to be action oriented and focus on children's encounters with everyday scientific verbs, such as rolling, rather than only focusing on their encounters with tangible objects.

Although these studies using new materialist perspectives have taken the stance that new materialism enables new ways of becoming scientific, gendered becomings are not engaged with.

Empirical explorations of gendering as co-creating science identities in education

Studies that engage in children's gendering *explicitly connected with science and science identity* are usually focused on the school level than on preschool settings. In these studies, gender is addressed using socioculturally perspectives. Typically considered is how individuals (teachers and students) relate to broader sociocultural characteristics of science as a community (Carlone 2004) and how students (manage to) relate to and identify with traditional views on science (Archer, DeWitt, Osborne, Dillon, Willis and Wong 2012). Results from these studies show how norms and discourses connected to science create the picture that some students are more suitable for science (white men/boys), while others (people of colour, women and girls) are deemed as less suitable (Brickhouse 2001). This stance makes it harder for girls to identify with science (Archer et al. 2012). The findings from contemporary studies using new materialist perspectives have shown how also the materialities at hand in the classroom or laboratory, together with gender discourse, co-create whether or not a student will be seen as suitable for science (Hussenius 2018). Although gendered science identity has been more commonly studied in relation to older pupils, this does not mean that similar issues do not affect preschool children. In earlier studies (Günther-Hanssen, Danielsson and Andersson 2019), we have addressed the idea that gendering cannot be separated from young children's scientific explorations and that, for example, processes of "doing girl and doing science" can be mutual. One conclusion is that if norms and discourses are not taken into account together with a focus on children's explorations with different materials, there is a risk that some ways of doing science and becoming scientific will be overlooked, especially doings, play, and places connected with femininity. This is prevalent also in natural outdoor environments and when children take part in the same activity or play (Günther-Hanssen 2018). Anna Günther-Hanssen et al. (2019) also show how the scientific content per se can take part in the co-creation of individual children's possibilities to act, explore and become in different situations.

This literature review sets the stage for additional studies to further explore, from a gender perspective, how children's identities, bodies, capacities, and agency are constructed in entanglements with scientific phenomena. In the next section, I provide an overview of the Swedish preschool system and study's research context.

Methodology and research context

Science and gender in the Swedish preschool

The Swedish preschool system has the same curriculum for children aged from 1 to 5 years (National Agency of Education 2018). 85% of these children attend preschool. Swedish preschool teachers complete a 3.5-year university preschool teacher programme; however, all the staff working in preschools does not have this degree. In 2018, 39.6% of the staff had a preschool teacher university degree. Another 30% had some kind of training in working with children, either at the high school level or teacher education for older students or another kind of educational training. The final 31% did not have any training in working with children (National Agency of Education 2019). All the staff works together with the children, but the preschool teachers have the pedagogical responsibility. In 2010, the focus on children's learning was strengthened in the curriculum, especially in science, mathematics, and language (National Agency of Education 2010). The Swedish preschool curriculum does not include specific learning goals. Instead, the curriculum formulates what the preschool should "offer" the children in each subject. In the curriculum, learning is described as strongly connected to children's play and explorations of their surroundings and not only to activities guided by teachers. Gender equality has been an explicit part of the curriculum since 1998, and it has since been stated that gender stereotypical roles should be counteracted in preschool. In spite of this, two recently published quality reports from the Swedish School's Inspectorate (2016) and (2017) show that both gender and equality issues, as well as science and technology, are areas in need of development in Swedish preschools. In a recent revision of the curriculum (National Agency of Education 2018), the preschool's work with gender equality is more explicitly described. While earlier versions of the curriculum stated the importance of gender equality over all, the revision more clearly addresses these issues in relation to certain areas, such as children's play and possibilities to make varied choices and broaden their interests.

Learning environments in Swedish preschools and in the preschool of the study

Historically, outdoor play is considered important in Swedish preschools (Ärlemalm-Hagsér 2010). Most preschools have their own yard with asphalt, grass, lawns, rocks, and trees. Throughout the year, preschool children daily spend time outdoors, either in the yard or on excursions. In this study, the children and teachers alternated between spending time indoors, in the preschool yard, and at different places near the preschool. Both indoors and outdoors, the children could often choose their locale and activities. The teachers considered the environment (inside and outside) important for children's learning and had arranged materials to allow open-ended explorations (Andersson and Gullberg 2014). For example, there were tubes for exploring sound and moving things with/in, paint and pens for experimenting with colours, glue and clay, sand—both in and outside, as well as

various construction materials. In the preschool yard, there were natural materials such as rocks and trees as well as a large swing.

Field study and data construction

The field study was conducted in a preschool outside a large city in Sweden, with a group of 25 5-year-old children (11 girls, 14 boys) and three teachers. During the field study, participant observations, including video recordings and field notes, were made over 5 months, with a focus on the children and the preschool environment. On average, I visited the preschool twice a week (visits lasting 2–6 h). I completed 155 h of observation and video recorded 12 h. During the field study, I moved around between the places where the children were. Sometimes I sought out activities that showed a potential for emergent science; at other times I sat and observed children playing/exploring. The field notes were guided by the research questions of the study, and I did not use a formalized observation guide. I conducted shorter, informal conversations with the teachers. After each visit, I transferred the video sequences to an external disk and typed my field notes. The field notes comprised of 40 word processed pages with a total of 19,233 words. I asked the children for their permission before I videoed and reminded them that they could ask for the filming to stop. If a child seemed uncomfortable with being filmed, the camera was turned off or the child was reminded he/she could ask for the filming to stop. In this way, the children's consent was sought on a moment-to-moment basis. Before the field study, a letter was sent to the children and their guardians with information about the study. During the first visit and again in the middle of the field study, I had a conversation with the class, gathered during circle/carpet time, about the study and the purpose of the visits and observations. The children were encouraged to ask any questions. Teachers and guardians received information about the study's aims and collection methods. The guardians were informed they could withdraw their children at any time as well as about the data management, before they signed a consent form. The guardians of five of the children did not grant consent; thus, I excluded the children from the video. f. The study adhered to the Swedish Research Council's principles for research ethics (Swedish Research Council 2011) and was approved by the regional research ethics board. My description of the preschool is purposefully vague and the photographs edited to ensure confidentiality of the locale and persons. Emily and Ben are pseudonyms for the children in this study.

Diffraction methodology and diffractive readings

The analysis uses Barad's diffractive methodology and diffractive readings (Barad 2007). Barad (2014) explains that diffractive analyses are a matter of looking for differences within phenomena, focusing on encounters, co-actings, and entanglements, and what these differences might do. Diffractive readings imply reading different insights (concepts, materials, parts of data, etc.) through one another (Barad 2003). Data are seen as "pieces" that have been "cut out" from the world's multiplicity. Data construction means cutting-together-apart (Barad 2014). However, the researcher is not the only agent in the making of cuts; the cuts are enacted intra-actively (together with the theoretical concepts, technologies, discourses, the data, and the children). The cuts separate some things from their entanglements, but at the same time, new entanglements are iteratively created as the cuts intra-act with the concepts, researcher, earlier research, etc., during the analysis. Both data and theoretical concepts are agentic and co-creating the analysis (Barad 2007).

Diffraction readings together with the selected data

During an early stage of the analysis, I reviewed and sorted the video sequences by location, that is, inside the preschool, the preschool yard, and excursions outside the preschool. The analytical process was commenced by constructing a list of the content in each video sequence to create an overview of the material. Then both the video sequences and field notes were sorted according to the specific places (rooms, corners) in the preschool, in the yard, and in the excursions where they were constructed. At first, I engaged with the data constructed together with two places in the indoor environment—a construction room which attracted mostly boys and a drawing table which attracted mostly girls (presented in Günther-Hanssen 2019). After this, I engaged in the gendered explorations together with a natural outdoor environment which the child group often visited on their excursions (Günther-Hanssen 2018). After this engagement with how scientific phenomena can co-create gendering processes in preschool, I re-read the data again to look for opposite situations, that is, situations where scientific phenomena co-created the children's agency and identities in a more empowering way. Sequences in which I identified scientific phenomena functioning as “empowering” playmates for the children (de Freitas and Palmer 2016) were chosen for a more detailed analysis. This regarded, for example, situations where scientific phenomena worked supportive for children in increasing their bodily capacities. One 4.5-min sequence was when Emily, the swing, acceleration, and various forces were co-acting. This sequence was also interesting because it was rare for a single child to be playing with the swing. Thus, this situation is an interruption of how “playing with the swing” was usually done during the field study. By analysing this sequence more closely, other possibilities for learning and becoming could come to the fore, as compared to the daily doings when the swing set area was full of children (described in the introduction). Furthermore, this sequence also meant an interruption of how the children often repeated certain doings during the whole field study. The video sequence of Emily and the swing has guided the analysis; however, a number of other video sequences (in total 13.5 min) in which many children were co-acting with the swing are also examined. Each video sequence is an agential cut (Barad 2014), a term I will use when describing how the diffractive analysis was enacted.

A sequence of agential cuts

Firstly, I watched the agential cut (video sequence) of Emily and the swing carefully and repeatedly. By cutting the video sequence apart into shorter video clips and screenshots, a sequence of agential cuts could be created and experimented with. A total of 111 screenshots were taken out, one each time a (clear) change in motion in the co-actings of Emily and the swing was carried out. Together with the screenshots, it became possible to look more closely and carefully at the video's details. These and the agential cuts, in the form of shorter video clips, then took part in new entanglements in various ways (Taylor 2013), for example with each other as many screenshots could be placed next to each other. They also intra-acted (Barad 2007) with the researcher, theoretical concepts, and so on, as illustrated by three following examples: (1) the moving and squeaking swing in the video sequence caused feelings of acceleration and force also in my (the researcher's) body and memories from swinging as a child were re-actualized. This directed me towards the embodied and affective dimensions in “becoming scientific”. The intra-activities with the video clips thus both changed my perception of myself

in the room as well as the knowledge production. (2) As different theoretical concepts were added, the agents in the video clips and screenshots could emerge in “new” ways. For example, it became possible to see beyond Emily (the human) as being the only one playing in the situation and to instead see a child, a swing, and various forces, all participating and playing *with each other*. (3) Together with the data, the thought of how materiality can co-create how identities materialize in our bodies (Barad 2003) emerged to be able to also include “things” like acceleration and velocity. This is one example of how also the theoretical concepts could “become” in certain ways within these intra-actions.

The sequences of agential cuts which I elaborated together with were cut out from their entanglements, both with other events in the preschool, and from events within the overall phenomena of Emily’s explorations and becomings with the swing. In this sense, it became easier to look for differences *within* the overall phenomena explored.

At an early stage of the analysis, the movements of Emily’s body and the swing were followed by focusing on how they co-acted together. This led to a sorting into five different agential cuts concerning how Emily co-acted with the swing: “from the ground”, “in the swing”, “jumping”, “side-swings”, and “under the swing”. The screenshots were also sorted based on these agential cuts. As this was being done, these five agential cuts (each consisting of both video and screenshots) were examined one at a time together with the notion of emergent science, as well as the different analytical concepts. This process made me notice how similar kinds of explorations appeared in all of the video clips and screenshots in which Emily was positioned on the ground (“from the ground”, “side-swings”, and “under the swing”).

From this stage, the diffractive analysis instead continued with three agential cuts (presented in the findings below), at first called “in the swing”, “from the ground” and “jumping from the swing”. Each of these three agential cuts was explored further together with the analytical concepts. During this exploration, the convergence of some of the analytical concepts and a certain agential cut proved to be especially productive. For example, the notion of scientific phenomena being creative playmates (de Freitas and Palmer 2016) together with the agential cut in which Emily co-acted with the swing from the ground became productive in relation to how Emily’s iterative pushing and pulling with the swing could be understood as part of a scientific approach—becoming the focus of Agential Cut 1. The concept of materialization (Barad 2003) together with the agential cut in which Emily was positioned in the swing became productive in relation to how bodily experiences of physical phenomena can be understood to “stay in one’s body”, and the focus of this agential cut (Agential Cut 2) “zoomed in” on bodily sensations of and with physical phenomena. The notion of posthumanist performativity (Barad 2007) together with the agential cut in which Emily jumped from the swing became productive in relation to how various agents, for example the gravel on the ground, could be understood as an agent co-creating Emily’s identity construction, which became the main focus of Agential Cut 3. The direction of the analytical work was also guided by earlier studies, for example the concept of emergent science (Siraj-Blatchford 2001) (especially Agential Cut 1), science learning as embodied practices (Areljung 2019) (especially Agential Cut 2), as well as the importance of an identity focus when it comes to science (Archer et al. 2012) (especially Agential Cut 3).

Throughout the analysis, it was also important to not only look closely at details concerning how the swing and scientific phenomena in the data worked as co-constitutive forces and, in this way, forget about discourse. Barad (2007, p. 207) reminds us that “explanations of various phenomena and events that do not take account of material, as well as

discursive, constraints will fail to provide empirically adequate accounts". Since the chosen data in this article do not include gendering processes in an explicit way, there is a risk that a focus on child-material relations during the analysis can overlook issues of gender (norms). To minimize this risk also Butler (1993), as well as earlier studies such as Kristina Andersson and Annica Gullberg (2014) and Heidi Carlone and Angela Johnson (2007) with their focus on norms connected to science and gender, has pushed me to also look at the norms and discourses enacted with the swing set area. This has not been done by using certain concepts from these studies (except that Barad's theory is informed by Butler's work), but to use their texts and studies as a reminder to include norms and discourse—even though these were hard to detect in the chosen video sequence. One implication of this is I reviewed a number of agential cuts (video sequences and screenshots) of the swing set area as it appeared on a daily basis. In this way, the chosen video sequence could be discussed together with the daily, repetitive doings with the swing—from which the chosen video sequence both are part of and differs from.

Findings

The findings are presented through the three agential cuts constructed during the analysis. In the first agential cut, focus is on the scientific method and emergent scientific inquiry. The second focus on bodily sensations of and with physical phenomena while swinging and the third emphasize how physical phenomena can take part in (gendered) identity construction. Finally, the findings from the three agential cuts are read through one another in order to create a synthesis of the overall phenomena of Emily's explorations and identity construction with the swing.

Agential Cut 1: scientific method and emergent scientific inquiry

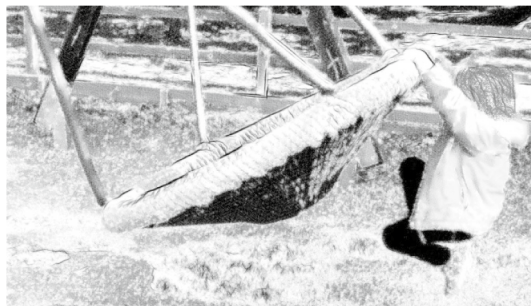
Together with the swing, Emily repeatedly made explorations in various ways from the ground. By placing her body in different positions, she explored how it was possible to make the swing move as well as how it acted and affected her body while moving. One of the techniques Emily used to make the swing move was to run forward, pushing the swing in front of her. As the swing reached its turning point, she quickly ran backwards to keep pace with the velocity of the swing moving back towards her.



Bodies pushing each other—Emily and swing, Emily and gravel.

The weight of the swing, its bars attached above in the frame, and the loose gravel under Emily's feet forced her to exert a lot of strength as well as a lot of force on the swing and gravel, while she ran and pushed—at the same time force was exerted on her body by the swing and gravel, pushing back at her. After the turning point, Emily at first had to run backwards while being pushed by the accelerating swing. Then she had to start pulling the swing backwards since its speed decreased as it approached the next turning point. Within these intra-actions (Barad 2003) of Emily's running-pushing-pulling body and the swinging-pushing body of the swing, the phenomena of velocity and force could make themselves known. From an agential realist perspective, this can be understood as one part of the world—the physical phenomena—making themselves intelligible to another part of the world—Emily and the swing (Barad 2007).

On many occasions during the video sequence, Emily also pushed the swing while standing still at different locations. Sometimes the swing lifted Emily's body from the ground. Thus, while playing with the swing, Emily pushed the swing and the swing pushed (and lifted) her.



Emily, swing and forces playing with each other.

Together with the notion of *scientific phenomena as creative playmates in children's play* (de Freitas and Palmer 2016), it becomes possible to see beyond Emily (the human) being the only one playing in the situation by exerting force on an object (the swing), and

to instead see a child, a swing, and various forces, all participating and playing *with each other*.

While pushing and waiting for the swing to turn and swing back, Emily had to adjust her position and time her movements to prepare for the velocity and weight of the swing, so it would not hit and hurt her. The velocity and height of a swinging swing/pendulum are dependent on whether it is tilted back and then simply let go of, or if a force is applied to it. In the first case, the swing/pendulum will lose a small amount of momentum as it swings back, and one can safely stand still on the same spot without being hit. In the other case, if force is applied to it, one has to adjust one's position in line with the swing/pendulum as it swings back. In the video sequence, it is clear that Emily already had this kind of bodily experience from earlier intra-actions with swings and force (Barad 2003). By placing herself in the right position and stretching out her arms, her body could be lifted up into the air and be played with, instead of being hit.

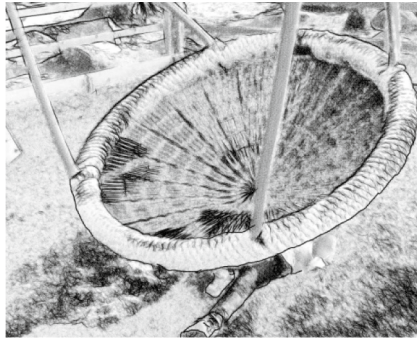
Emily also positioned herself by the side of the swing. From here, force could not be applied to the swing, or to Emily, by pushing. This meant that this position required other techniques for Emily to play together with the physical phenomena.



Forces iteratively applied by pulling (on the part of both Emily and swing).

At first, Emily ran from side to side with one hand on each bar. As the swing moved higher and higher, Emily had to release her grip with both hands and instead pull as much as she could sideways with one hand attached to one bar at a time as the swing moved by. As the swing turned back, she grabbed the other bar with her other hand and followed the swing in the other direction, while simultaneously pulling with her whole body. At the same time, the swing pulled her body from side to side. Emily's new position by the side of the swing enabled her to approach the same phenomena—how to make the swing move by applying force—via another technique, which in turn allowed the phenomena of force and velocity to make themselves intelligible to her and the swing in a slightly different way. By placing her body under the moving swing, Emily could expand her explorations even further.

Bodies of Emily and swing in touch without touching each other



Experiencing the movement of the swing from a new perspective.

At first, Emily lay still while the swing moved back and forth above her body a couple of times. Then, at the right moment, as the swing moved towards the turning point above her feet, she quickly rose up on her knees and crawled to the side before standing up again. Instead of playing together by pushing or pulling each other, in this situation, Emily's body and the swing co-acted without physically touching at all. However, this does not mean they were not "in touch" (see Barad 2012) with each other. Rather, here Emily and the swing are two moving bodies, closely co-acting, choreographed together with velocity. As such, velocity can be understood as a creative and important playmate (de Freitas and Palmer 2016) in this situation as well. Furthermore, because the position under the moving swing meant a greater risk of Emily being hit, one can imagine that these intra-actions created sensations and feelings in Emily's body (and mind) such as excitement and perhaps a little bit of fear and/or courage. Regarding emergent scientific inquiry, in addition to hands-on explorations of and with different materials, affective experiences are also considered to be important for children's motivation and engagement (Cremin et al. 2015).

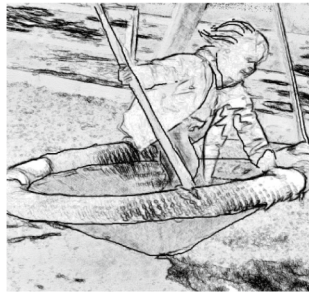
The repetitiveness, with which each technique was explored, rendered Emily's doings coherent with an emergent scientific approach or method (Conezio and French 2002). Emily also used this method when she placed herself in the moving swing several times.

Agential Cut 2: bodily sensations of and with physical phenomena

When in motion, a swing iteratively changes in velocity. That is, its speed increases between the first turning point and the way back/down and decreases as it rises up towards the next turn. For a swinging body, the force required for acceleration acts on, and affects, the whole body, which is why swinging (or accelerating) can be felt in your stomach. When a swing is hanging straight down, the force of gravity is experienced the most. At the turning points for a swing/pendulum, "the force from the chain counteracts the radial component of the force of gravity" (Pendrill and Williams 2005, p. 527), which make you experience your body as lighter or, perhaps, if you swing high, almost weightless.



The swing is accelerating.



Body feeling heavier.



Body feeling lighter.

While swinging, Emily experienced the constant change in velocity working on/through her whole body. This means that one of the bodily sensations Emily experienced while in the moving swing was the interchange between feeling heavy and light, over and over again. These bodily sensations are so strong that many adults can recall them and “feel the swinging in their body” (Pendrill and Williams 2005), even though many years have passed since they engaged in this activity as children. When thinking with Barad (2003), these bodily experiences, of and with forces experienced when swinging as a child, can be understood as being able to materialize in one’s body and then being re-actualized over and over again. In this sense, just thinking of swinging can cause embodied sensations of earlier intra-activities (Barad 2007) with force.

In order to swing and keep a swing going, children need to learn how to entangle with various forces (de Freitas and Palmer 2016), as well as how to overcome the inertia of the swing and their body by changing their centre of mass. In the video sequence, however, Emily made the swing move using other techniques. Each time before getting on the swing, she ran along with it until it was swinging fairly high and then she effortlessly jumped onto it without causing it to slow down. It was evident that she had earlier bodily experiences of intra-acting (Barad 2007) with swings, velocity, and acceleration and that she had embodied knowledge concerning how to move and balance her body on a turning and accelerating swing. This was evident, for example, in the way that Emily easily managed to crawl to the edge of the swing and then assume an upright position. However, following Barad’s (2010) thoughts about the inseparability of matter and meaning, embodied knowledge, such as in this example, cannot be seen as something that belongs to an individual person (Emily) who has learned something (physical phenomena) by using her body. With this perspective, Emily’s body, the swing, and the physical phenomena (matter) instead come to the fore as inseparable from her emergent knowledge (meaning). Although Emily was the one with this knowledge about velocity and acceleration, her knowledge would not exist without her close, bodily entanglements and co-actings with these physical phenomena and the swing. Nor would her knowledge exist without her bodily capacities to sense, experience and be responsive to her body’s entanglements with the swing and forces.

Emily did not only repeatedly place her body in the moving swing, and she also repeatedly jumped from it, which is the focus of the final agential cut below.

Agential Cut 3: identity construction in play with physical phenomena

Each time Emily got on the swing, she finished her swinging with a high, long jump. To disembark from the swing by jumping, Emily first let go with her hands, and then at the right moment, just before the swing's turning point, she pushed her body up into the air.



Travel through the air.

As her body travelled through/with the air, Emily made a swooshing sound with her mouth. Her happy facial expression after each landing can be interpreted as these jumps co-created positive feelings for her—for example, the thrill of “being in the air” high above the ground, as well as feelings such as joy, satisfaction, and empowerment over what her body could do, and that she was brave enough to do it—that is, take a long and high jump from a moving object positioned some distance above the ground. However, if we look at Emily’s jumps together with posthumanist performativity (Barad 2003), being brave enough to jump is not a quality that *belongs* to Emily as an individual. Instead, the swing and physical phenomena come to the fore here as necessary agents for her identity construction as well as for her agency and ability to act with, and occupy, the swing, the air, and the ground. Moreover, the layer of gravel on the ground in the whole swing set area can be seen as an important agent in the situation.



Bodies of Emily and gravel mutually exerting force on each other.

Upon each landing, Emily's body exerted a certain amount of force on the gravel, as the gravel mutually exerted the same amount of force on her body. The same jump onto a harder surface, such as asphalt, would have meant the same amount of force, but over a shorter period of time, and her landing would then have felt harder on her body. In this sense, the gravel can also be seen as an agent (Barad 2003) co-creating the fact that Emily jumped from the swing. Furthermore, the fact that Emily was wearing sneakers also made her feel the force less in her feet. Had she been wearing, for example, sandals with a very thin, hard sole—which some of the girls at the preschool sometimes did—the force enacted during the landing would have been felt much more acutely (as pain) in her feet. Accordingly, the kind of shoes a child wears can co-create what the child can do (without feeling pain) and as such also how that child's identity is constructed—as someone who can (or dares to) jump or perhaps as someone who cannot (or does not seem to dare). The fact that Emily was the only human agent in the situation who was playing with the swing also needs to be highlighted as important to what became possible to do and become for her. Within the *apparatus of bodily production* (Barad 2003) going on in the chosen video sequence, gender discourse was not an explicit agent with regard to compelling Emily to, for example, use her body in a cautious manner in line with gender stereotypical norms. However, the situation can still be understood as gendered, since Emily's possibilities to act and use her body in various ways, as well as for her and her body to become brave and strong, were enabled by the fact that she could entangle and co-act with the swing and physical phenomena and occupy the whole swing set area, all without disruption. On a more daily basis, when the area was full of children, it was not common that all the children got the same opportunities to explore and become. In the example mentioned in the introduction of the article, Emily had to fight to get the spot by the bars of the swing and the opportunity to climb them. That is, on a daily basis, there were other apparatuses of bodily productions including gender norms in a more explicit manner, enabling and hindering different children from co-acting with the swing in certain ways. However, although Emily was the only human agent in the video sequence who was physically co-acting with the swing, she was not the only human agent in the swing set area. My presence as an observer also co-created the situation.

Recognition as part of a positive (science) identity



Searching for recognition.

After each jump, Emily turned her gaze and smiling face towards me. It was not only the doings, explorations, and becomings that mattered to her per se—it was also important for her to share these things with another human. My presence meant that Emily did not only have the opportunity to experience herself as brave, strong, and skillful as she co-acted and explored together with the swing and physical phenomena—she was also perceived as such by someone else. When it comes to science contexts for older pupils and professionals, studies such as Lucy Avraamidou (2019a) and Carlone and Johnson (2007) argue that being recognized by others is an important part of a person's ability to create a positive science identity. Emily's gaze towards me showed the importance of recognition for young children as well—however Emily's search for my recognition was not consciously connected to science at this stage. Her gaze towards me rather showed that she found it important that someone saw what she could do with the swing and her body—which in turn cannot be separated from the physical phenomena she was experiencing and exploring. The fact that I was holding a camera, filming her (which she had agreed to) also needs consideration. Her gaze and smile after each jump can also be understood as directed towards the camera. However, the camera does not make the recognition less. Since I was holding the camera in front of my body, both my face and gaze was visible to her, as was the gaze of the camera—she had two gazes directed at her. Furthermore, during the field study, it was common that the children called for recognition from other children. For example when there were many children in the swing set area, both Emily and the boys hanging in the bars of the swing, called for the other children's attention. At that time, however, as Emily was hanging "upside down", no one of the other children reacted. As one of the boys did the same thing a moment before, he was highlighted by other children. The children's recognition of each other did not have anything to do with science—however, since children often use their whole body in their explorations of and with scientific phenomena, to be recognized "overall" and for what one can do with one owns body, can also be considered of importance for children's construction of a positive emergent science identity.

To conclude the analysis, the three agential cuts are read together in the next section, in order to create a more entangled picture of the overall phenomena of Emily's explorations and identity construction with the swing. To further explore how the overall phenomena differ from the more common situations when there were many children by the swing, examples of these are also presented below.

Synthesis of the overall phenomena of Emily's explorations and identity construction

When looking at the three agential cuts as one phenomenon together, it becomes clear that it was not only in Agential Cut 1 that Emily constantly both tried new ways to co-act with the swing and also repeated each way before she switched, rather this was a process that continued throughout her play. This means that Emily's bodily experiences and sensations, as well as her identity construction, cannot be separated from her emergent scientific inquiries, nor can they be separated from each other. Repetition is an important part of the scientific method—however, repetition is also an important part of identity construction and how our identities come to be intelligible to others (Butler 1993), for example as girls, boys, and/or as scientific. With each change and new way of co-acting with the swing, it became possible for Emily's identity to also constantly be constructed in a slightly different way. In this sense, acceleration, velocity, and force did not only work as creative playmates in Emily's scientific explorations (de Freitas and Palmer 2016), but also as important

playmates in her identity construction. In the explorations with the swing and physical phenomena, Emily could mutually expand on her bodily capacities and, for example, become brave and strong. As such, the scientific phenomena did not only co-create Emily's emergent science identity, but also her identity construction "overall" in an empowering manner. In this sense, scientific phenomena do not only materialize in one's body as embodied memories or knowledge with and about them, but also as part of an embodied identity.

It is possible to imagine that the feelings Emily felt during her play with the swing also could materialize as a part of her emergent science identity. At this stage, it is not possible to discuss Emily's feelings as something this study shows evidence for. However, since feelings are stated as being an important part of emergent scientific *inquiry* (Siry and Brendel 2016), the role that feelings might have also for children's emergent science *identity* is an interesting and important topic to discuss and elaborate on further. From Emily's happy facial expressions and energetic movements of her body, one can imagine that Emily's experiences playing together with the swing and physical phenomena from various positions and in various ways caused feelings of excitement, satisfaction, and feelings of being free and independent—and that these feelings also could materialize in her body (Barad 2007) as positive, empowering, embodied memories of the situation. If similar experiences were to continue being iteratively created for Emily, these kinds of feelings might keep on co-constructing her emerging science identity, as well as her identity in a broader sense, in an empowering manner. This would mean that, when adults, like you and I, think about swinging as a child, mutually as the sensations of earlier intra-activities (Barad 2007) with acceleration and force can be re-actualized in one's body and mind, the identity and feelings mutually created at that time would also be possible to re-actualized again.

Furthermore, through posthumanist performativity (Barad 2003), it becomes possible to see how feelings and experiences of one owns identity construction are not pre-existing and internal, but are dependent on which agents that make themselves intelligible in each situation and how (Barad 2007). As Emily and the swing were playing with each other, the phenomena of acceleration, velocity, and force could make themselves intelligible—that is, their "existence" could be felt and experienced by Emily, and it became possible for her to entangle, play, and co-act with them in various ways. In the more common situations when there were many children by the swing, the children had more one-dimensional positions or opportunities, for example "the position" as someone pushing the swing, someone sitting on the swing, or as someone jumping or climbing the bars of the swing. On a daily basis, acceleration, velocity, and force made themselves intelligible in a less varied way to each child. The opportunities to play and become together with the swing as there were many children there were, except from the more limited space, also co-created due to the fact that in these situations gender norms "made themselves more explicitly known". In these situations, gender norms co-created the children and were also recreated by the children in the iterative doings performed together with the swing set area. This was apparent, for instance, in the way that individual children repeatedly got similar and more one-dimensional opportunities and in that Emily had to fight to interrupt these iterative doings to get a spot by the bars of the swing. This is also seen in the different reactions she and the boys elicited from the other children when they climbed the bars—that is, being noticed or overlooked. When Emily instead was the only human agent co-acting with the swing, gender stereotypical norms were not evident or felt in the same way.

Since Emily moved around and co-acted with the swing from various positions, she had different bodily experiences together with the physical phenomena—as such many intra-actions with physical phenomena that could materialize in her body and co-create both emergent scientific understandings and an emergent science identity. However, the way in

which her mutual embodied knowing and identity construction will be able to materialize in her body also depends on what happens in the future. In other words, it depends on how often Emily will have the opportunity to become strong, skillful, and brave, and feel empowered together with the swing and physical phenomena in the future, compared to how often she will have to fight to get a spot by the swing. If she more often would have to fight for a place, other (gendered) identities might instead materialize in her body and then be re-actualized for a long time in connection with (scientific) inquiry, swings, and her agency and bodily capacities. Lastly, Emily's search for an observer's gaze in Agential Cut 3, as well as when she was hanging upside down and called for the other children's attention in the example in the introduction of the article, shows how her (science) identity, as well as her understanding of her capacities to act and explore, is dependent on if and how her play and explorations are recognized by others (teachers and other children). The importance of recognition as a child can be connected to the results of Avraamidou (2019b) showing that a person's (science) experiences from childhood may impact science identity trajectories later on in life.

Conclusions and implications for practice

By combining *new materialism*, *emergent science*, *a conceptual approach to physics*, and *gender theory*, it was possible to create a multifaceted understanding of the overall phenomena of Emily's explorations and identity construction with the swing. By using a conceptual approach to physics (Hewitt et al. 2008) together with new materialism, various physical phenomena could be detected and understood as creative playmates (de Freitas and Palmer 2016) in Emily's play. Moreover, together with Barad's notion of intra-activity (Barad 2007), the physical phenomena were not there as "pre-existing fixed content", instead they—due to Emily's iterative bodily co-actings with the swing—could make themselves intelligible to her and the swing. This is similar to de Freitas and Palmer's (2016) argument that scientific concepts do not come from the outside and are not applied by an adult, but are instead "there" for children to play with. Emily's play and explorations together with the swing, gravel, etc., made it possible for her to explore velocity, acceleration, and force and to "become as scientific". This means that becoming scientific and/or creating a science identity is something that is enabled in entanglements and not something one can do by oneself (Areljung 2019). Even though the results of this study (among others) show how children can construct knowledge through playing and experimenting with, as well as experiencing, scientific phenomena, many researchers also argue for the need of teachers to connect children's explorations to scientific concepts. If this is not done, studies argue, children will not develop deeper scientific understanding (Larsson 2013) and create knowledge in line with the common and shared views of scientific knowledge (Gomes and Fleer 2018), and as such, it would be harder to "become as scientific". This could perhaps be seen as two different views or paths concerning young children's scientific explorations. At one hand, it is shown how young children already are in the making of creating (embodied) scientific knowledge, and on the other hand it is stated that their doings need to be translated into correct concepts to align with teachers and (preschool) education goals.

Since science plays an important role, not only in education, but in society and peoples' everyday lives, it does become crucial that teachers help children to make phenomena scientific and children into scientific knowledge formation. That children are able to navigate and take part in scientific contexts as well as understand shared views

of science (i.e. certain models of knowledge) is in fact a democratic issue (Fensham 2004). In the same time, it is possible to also understand the situation from “the other way around”. For teachers’ to understand the embodied explorations children experience together with scientific phenomena, scientific concepts work as tools firstly for *them* and secondly for the children. Regarding Emily’s explorations and play with the swing, together with knowledge about scientific phenomena, a teacher could have highlighted that Emily was engaged with acceleration and force and in the same time let Emily’s play, explorations, and discoveries be the point of departure (Siry 2013). Recognizing scientific content and phenomena within children’s ongoing play can thus be a tool for teachers to learn about children’s explorations and becoming and open up for multiple understandings concerning how it is possible to “become scientific” (Nomikou, Archer, and King 2017). To problematize traditional norms connected to science and expand the ways in how one can “be scientific” is also a democratic issue. Here, to become scientific in line with common norms of what it usually mean to “being scientific” can be considered as one, or a few, among many other potential ways. I argue that these two approaches for teachers, concerning how to handle scientific phenomena and concepts, are both important and can complement each other in important ways. However, from the results of this study, I also argue that both of these approaches need to consider gendering processes.

The present findings show that scientific knowledge is not enough for teachers and that knowledge about norms connected to both science and gender are equally important (Gullberg, Andersson, Danielsson, Scantlebury and Hussénus 2018)—especially when highlighting how “becoming scientific” can be something multidimensional and not fixed. The explored situation was rare. On most occasions, Emily did not get the same opportunities to explore and become with the scientific phenomena in the same way. As there were many children at the swing set area, the more limited space as well as the fact that gender norms “made themselves more explicitly known” in these situations, the explorations became more narrow for the individual child. One important conclusion from the study is that teachers need to be attentive to how gendering processes co-create if, how, and when scientific phenomena *get to make themselves intelligible* in different situations to different children (Barad 2007), due to individual children’s different (and gendered) opportunities to claim space and co-act with materials in various ways. In the same time, it is also important that teachers are open and attentive to the fact that scientific phenomena can make themselves intelligible to children during the most unexpected (to adults) situations and places (Günther-Hanssen et al. 2019), as well as during situations that suddenly and rapidly appear which do not belong to the daily doings, norms or routines of the preschool—just like in the case of Emily and the swing. If it is not taken into consideration that science can be “done” in various ways—that is also ways that not always goes in line with traditional norms connected to science, the false picture could be created that some children, already at preschool age, are more “suitable” for science, while others are created as “less suitable”, just as can occur in school and higher education (Brickhouse 2001). This picture could then cause preschool teachers to overlook some children’s scientific inquires, even during teacher-led activities, just as teachers have been shown to do in relation to older students (Carlone 2004). In other words, the work with children’s construction of an emergent science identity needs to start in preschool if we are to counteract traditional norms and discourses connected to science and gender. These norms and discourses are not something that “come with” older children in school or only are introduced by adults, but are instead already in the making and remaking within children’s co-actings with the material-discursive environment at preschool (Günther-Hanssen et al. 2019).

In line with Haus (2018), Areljung (2018), and de Freitas and Palmer (2016), the present findings show how Emily's emergent scientific inquiries included, as well as co-constructed, her whole body. Thus, if teachers are to support young children's construction of an emergent science identity, they need to consider the whole child. Future research should explore how teachers can engage in children's embodied play with scientific phenomena, with the aim of empowering the children, their bodies, capacities, and (science) identities. In line with previous results (Klaar and Öhman 2012), the present findings show how young children are dependent on the use of their own bodies to engage with scientific phenomena—as well as how children's bodily explorations of and with their surroundings can be something joyful and empowering. The way in which Emily, after each jump, searched for my recognition, and how she called for recognition from the other children as she was hanging in the bars of the swing, clearly show that what she *managed to do with her body* (while also playing with scientific phenomena) was of great importance to her. This is why gender theory and perspectives on how bodies get constructed, restricted, and enabled are of particular importance to preschool science.

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