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"Drawing the leaves anyway": Teachers embracing children's different ways of knowing in preschool science practice

Sofie Areljung, Christina Ottander & Karin Due

Introduction

In many countries, for example Sweden, early childhood education (ECE) places increasing emphasis on learning specific subjects, and science is one of them (OECD 2006). This means that ECE responsibilities are shifting from a main focus on caring to also including teaching subject content knowledge. With this shift follows discussions of what science education for the youngest children should be. One question is whether science education in early years can be something in its own right, and based on ECE conditions and traditions, rather than formed by reproducing traditions from school science (e.g., Siraj-Blatchford 2001). In our view, the question of science education for the youngest children is a matter of combining different practices. Here we draw on Wenger's (1998) idea of practice as a social process of maintaining and developing a shared enterprise, for example the enterprise of preschool pedagogy, in a certain community. The practice includes routines, symbols, artifacts, conventions and stories. Over time, the practice generates a history of what are valid ways of knowing and acting, some in form of explicit guidelines and some in form of tacit agreements. In order to be a legitimate part of the community, one has to negotiate this shared history. Though the collective history produces borders "around" the practices, Wenger (1998) argues that different practices can be combined through translation and alignment between perspectives, which is interesting in the light of combining science with preschool practice.

Seen from a gender perspective, there are potential tensions between the practices and traditions of preschool and those of science. Previous research has shown that science practice is associated with masculinity (Keller 1985, Archer et al., 2012), and preschool practice (Swedish school form for children aged 1-5) with femininity (Tallberg Broman 1991, Gillberg 2009). This paper takes its starting point in acknowledging the symbolic level of gender: thus how we associate femininity and masculinity with objects, qualities and practices (Harding 1986). We argue that the symbolic level is important to take into account, since the differently gendered practices could cause strain when combining science with preschool practice. Here we especially think of gendered views of knowing – the preschool tradition of emphasizing the subjective side to knowing (Thulin 2006) and science tradition of emphasizing the

objective side to knowing (Keller 1985). These views are increasingly important as the responsibility to support children's subject learning, including science learning, is growing in preschool.

We see two main reasons for why we need to examine if and how Swedish teachers combine science and preschool practices into *preschool science practice*. Firstly, acknowledging the symbolic level of gender, there are potential tensions between the practices of preschool and those of science, especially when it comes to views on knowing, that likely influence how teachers combine science and preschool practice. Secondly, since the Swedish curriculum for the preschool was recently revised, putting more emphasis on science teaching, there are reasons to believe that such tensions will become more critical. These reasons will be elaborated upon in the following paragraphs.

Science education for young children

In the last decade, the interest for research in science education for young children has increased, as seen in international conferences where particular strands and special interest groups have been formed. Studies in the field often refer to science in "early childhood education", which generally includes children up to age 8, and where school science often operate as a model in research. However, since early childhood education also include preschool (children aged 1-5 years), we see a need to elaborate our ways of describing, thinking, and communicating about science for the youngest children. In discussions concerning science education for children there is often no distinction made between primary school and preschool science. The question of what science education for the youngest children can be, is crucial in order to develop practice and also to the research discussion in the field. Among the scholars who address the question is Siraj-Blatchford (2001), who proposes the concept *emergent science* to frame a science curriculum for the youngest children that stresses exploring rather than conceptual knowledge. Johnston (2008) uses this concept to highlight how children's scientific skills, attitudes, understandings and language are promoted through shared investigations. Eshach and Fried (2005) have suggested that science education for the youngest should have the goal of providing children with a wide range of experiences of phenomena and material. They argue that these "reservoirs of experiences may gradually become organised in rich concepts" (Eshach and Fried 2005, p. 322). We believe that these ideas step away from school science traditions and make way for preschool to claim a way of working with science that is developed in close relation to the preschool's conditions.

Extensive research within the field of early childhood science education has concerned the qualities of preschool/primary teachers, showing teachers' negative attitudes towards, as well as low confidence and insufficient content knowledge in, science (e.g., Garbett 2003; Spektor-Levy, Baruch, and Mevarech

2013). Fleer (2009) notes that many such studies are framed from a constructivist perspective, with a strong focus on the individual teacher's lack of content knowledge. Fleer reframes the problem by viewing early childhood science as embedded in a cultural-historical practice, and in a study of teachers and children working with science, Fleer points out how the teachers' beliefs about how children learn – and beliefs about the teacher's role in this learning – matters more than their concept knowledge when it comes to children's conceptual development in science (ibid.). Recent Swedish studies point in the same direction, articulating the importance of the preschool culture when teachers attempt to implement science in practice (Sundberg and Ottander 2009) and the importance of pedagogical competences, other than content knowledge, such as building on children's knowledge and asking questions that stimulate further exploration (Andersson and Gullberg 2014). Further the traditional portrait of science as a set of objective facts has been contested by researchers such as Siry (2014), who suggests that science in early years education should rather be portrayed as being complex, including dimensions of emotions, experiences and histories. Bearing this in mind, we find it necessary to study science as a practice, thus as social processes building on a shared history of what are valid ways of knowing and acting (Wenger 1998).

Gendered practices of preschool and science

The practices of science and preschool can be seen as gendered. We primarily draw on Harding's (1986) accounts of how gender operates at structural and symbolic levels. The structural level regards division of labour – i.e., where women and men are found in society; in what workplaces, in what work positions and in what parts of the public and private spheres. Here Swedish preschools serve as examples of sex-segregated workplaces as 97 percent of the staff are women (Statistics Sweden 2014). The symbolic level of gender regards how notions of masculinity and femininity are intertwined with how we perceive and communicate about objects, qualities and practices, regardless of their connection to biological sex. Gillberg (2009) points out that the social practices in preschool carry notions of femininity, which creates norms regarding how preschool should be – and thereby constrains what one can do in preschool. The feminine notions of preschool practice can be traced to the development of the preschool teaching profession. Tallberg Broman (1991) shows that, in Sweden, the preschool teaching profession has developed in close connection to ideas of the nature of women, especially ideas of women's predispositions for caring and nurturing. The current curriculum states that "preschool should be characterised by care for the individual's well-being and development" (Swedish National Agency for Education 2011, p.3) and in the section on development and learning it is said that care should form an intertwined and well-balanced trinity together with socialisation and learning. Though inferior in the first

70 years of the last century (Lenz Taguchi 2000), the learning part of the trinity has steadily increased in steering documents since then, notably in the first formal curriculum in 1998 and the revised curriculum in 2010 (Swedish National Agency for Education 2006, 2011). However, a recent investigation of how Swedish preschools work with their pedagogical responsibility, show that, even though a majority of the preschools practice a well-balanced combination of learning, socialisation and care, there are several examples of learning being down-prioritised in favour of caring (Swedish Schools Inspectorate 2011). Two Swedish studies illustrate this phenomenon, i.e. how the goal of caring for living organisms – animals in one case (Thulin 2011) and a tree fungus in another (Sundberg et al., 2015) – overshadows the goal of learning about the traits and functions of the different organisms. Referring to that phenomenon, Thulin (2011) argues that the teachers' adjustments to fit existing ideals of "good preschool practice" can lead to the science learning object being used as a tool for a goal that is closer to the preschool ideals.

When it comes to structural and symbolic gender associated with science practices, feminist scholars have exposed the historical disjunction between femininity and science, both by drawing on the lack of women in the history of science, and by showing the connection between science and masculine-coded qualities such as detachment and rationality (Keller, 1985). This branch of research is often referred to as feminist critique of science, and is prominent in the group of science education literature that emphasise "reconstructing the nature and culture of science" as strategy to engage girls in science (Brotman & Moore 2008). Aiming to make science more accessible to girls and other subordinated groups, these studies call for classroom pedagogies to draw attention to science not only as content and method, but also to challenge ideas of science being "men's work" as well as ideas of science being objective and value-free (ibid.). Archer et al. (2012) propose that the dominant associations of science with masculinity and intelligence constructs science as a field with only a narrow opening for girls. Accordingly, we argue that it is important to recognise that masculine-coded notions constrain what is possible to think and do in science practices, and thereby also in preschool science. This is why we regard symbolic gender crucial to our study.

Power relations and epistemologies related to preschool and science

Through historical analyses, Hirdman (2001) has emphasised that what is perceived as masculine and feminine is often *kept apart* and perceived as opposites in our society. The masculine is generally perceived as superior to the feminine, and usually makes up the societal norm. If we regard this in light of how gender operates at a symbolic level, there are reasons to believe that it can be difficult to combine masculine-coded science practice with feminine-coded preschool practice. Further, Harding (1986) has

pointed at the superior position that science, personified in the scientist, has in our society when it comes to credibility and power. With this follows that qualities connected to science, such as the above-mentioned detachment and rationality, are perceived as superior to non-science qualities such as emotionality. Hirdman's and Harding's perspectives thus shed light on the potential power difference between science practices and preschool practices. Such power relations might bring feelings of resistance towards science into the teachers' process of implementing an extended teaching responsibility in preschool.

Regarding the power relations of science and preschool, one important aspect is the ideas of knowledge and knowledge production that are dominating in the different practices. For the present study we are particularly interested in views on the relation between the knower and the known. How involved is the learner in what she or he learns? Does she or he learn "at a distance" or is learning personal, where the learner is unseparable from what is learnt? This is an important issue in light of Thulin's (2006) discussion of the Bildung ideal of preschool. Thulin points out that the preschool ideal traditionally has been leaning towards subjectivity, focusing who the child will be, compared to – and positioned in relation to – school ideals of objectivity, focusing what the child should know. The school ideals could thereby be related to the objectivity claims often associated with scientific knowledge production.

Following the international trend of incorporating more learning goals in early childhood education, the science curricula for the youngest children are currently undergoing reformation. In view of the above-mentioned power relations between, and contrary gendered practices of, science and preschool, the expanded responsibility for teaching science in Swedish preschool might cause tensions and resistance within the practices. We assume that the expanded responsibility calls for negotiations among staff regarding what science for preschool could be. In such negotiations lies the potential for challenging traditional views of science, and innovating new ways of framing science content. By examining preschool teachers' talk about activities concerning science content, we may develop a more nuanced vocabulary for describing the science practices taking place in preschool, and also a deepened discussion about the tensions and possibilities that occur in the meeting between science practice and preschool practice.

Opposite pairs influencing our thoughts about the world

One significant strand in the feminist critique of science discourses regards how dichotomies, mutually exclusive pairs, operate at a symbolic level in separating science from non-science. The Western traditions of dividing the world in dichotomies have been debated on a philosophical level for a long period of time.

Schiebinger (1989) shows that the traditions can be traced back to the ancient Greek philosophers who organised the world in dichotomies such as light/dark, good/bad and man/woman. The meanings of the dichotomies have changed over time, but generally the first word is perceived as superior to the second. The dichotomies have been challenged by philosophers who suggest that they do not represent reality and should be dissolved. Already in the 1910s Dewey criticized the rational/emotional divide, arguing that both cognition and emotion are important parts of learning and that they are not mutually exclusive (Dewey 1916/1966). The dichotomies have also been challenged by several feminist scholars (e.g., Harding 1986). Schiebinger (1989) argues that in Western history the boundaries between science and non-science have partly been upheld by dichotomies such as reason/feeling and fact/value, where the first word is associated with science. By mapping gender onto these pairs, Schiebinger shows how the science/non-science dichotomies correspond to ideas of masculinity/femininity. Keller (1992) points out that one main goal of the feminist critique of science has been to undermine the dichotomies, and researchers such as Traweek (1992) have exposed that the dichotomies do not reflect what is actually done, and not done, in science practices. Traweek's empirical work shows that when physicists in high energy physics organise research, the decisions are often based on irrationals grounds, which contradicts the common message of physics knowledge production being rational, based on systematic and person-independent experiments.

There are few examples on empirical work in science education research where dichotomies have been used as a starting point in analysis. When dichotomies do occur as central parts of empirically based studies it is often in the results section, where the researchers show how dichotomies have emerged as thought figures that operate in discourses found in the data, e.g. Ideland and Malmberg's (2014) search for dichotomies connected to otherness in school books on environmental education. One interesting exception is the action research conducted by Hildebrand (1998), who introduced unconventional writing assignments, for example poetry, in science class. The motive behind this was to disrupt the hegemonic writing practices that are connected to the "left-side" concepts in dichotomies, such as objective and logical. Hildebrand's intention was that students should be able to move between the science/nonscience concepts – that is for example, between objective and subjective – when working with science, and the concept pairs are thus present already in Hildebrand's research design. Seeing that dichotomies have influenced common perceptions about science, and that they are associated with gendered practices, we find such concept pairs useful as reference points for analysis of teachers' talk about science in preschool. Yet our working hypothesis is that both sides of the concept pairs are possible in preschool science practice.

Aim and research questions

In this study we use two concept pairs, objective-subjective and logical-intuitive (exemplified by Hildebrand 1998, p. 348), to analyse the empirical material. The reason for choosing the two concept pairs objective-subjective and logical-intuitive in particular is that they concern views on knowing. Such views become increasingly crucial as the preschool responsibilities transits from mainly care to also include teaching science. What counts as valid ways of knowing is something that likely differs between preschool practice and science practice. This since preschool practices are associated with femininity at a symbolic level, that is, with caring and the subjective sides of knowing, while science practices are associated with masculinity at a symbolic level; with objective sides of knowing. An important point to make here is that "intuitive" and "subjective" are not new aspects of science education, as most science curricula promote students' knowledge about the nature of science (NOS). According to Abd-El-Khalick, Bell and Lederman (1998, p. 418), understanding NOS includes knowing that scientific knowledge is subject to change, theory-laden, based on empirical evidence, and "partly the product of human inference, imagination and creativity".

The goal of this study is to contribute to the discussions of what science in preschool (children 1-5 years old) can be. We seek to contribute knowledge about if and how teachers combine science practice with preschool practice, and to contribute broadened, and more nuanced, ways of communicating about the science practices taking place in preschool. This by taking in account the symbolic level of gender when it comes to practices of preschool and science, especially regarding views on knowledge. Our aspiration is that this perspective will deepen the discussions about science in preschool and thereby empower teachers in their work of joining science learning goals with preschool practice.

Thus, aiming to contribute insight to how teachers combine science practice with preschool practice, this study explores *how teachers' talk about science in preschool relate to possible ways of knowing.* Further we explore (*2) how teachers handle the possible tensions between preschool practice and science practice.*

The Swedish context

In Sweden the preschool is a school form for children aged 1-5 years, of whom 83 per cent are enrolled. For the age group of 4-5-year-olds the share is 93 per cent (Swedish National Agency of Education 2014). The preschool was officially included in the Swedish education system in 1998 and in the first curriculum for the preschool, the science content focused on nature and its cycles, animals and plants (Swedish National Agency for Education 2006). In 2010 the curriculum was revised, implying an emphasised

science learning mission. The biology content remained, but the emphasis on the child's own involvement in processes in nature was no longer explicit, and new were the formulations regarding "how people, nature and society influence each other" as well as on children's understanding of "simple chemical processes and physical phenomena" and "relationships in nature" (Swedish National Agency for Education 2011, p.10). Another addition to the curriculum was that children should practice "their ability to distinguish, explore, document, put questions about and talk about science" (ibid.).

Data production and analysis

In order to respond to the research questions, we needed material where preschool teachers discuss science in preschool. In the current study the material consists of video-stimulated focus group discussions. The study is part of a larger project where material has been produced in collaboration between six researchers and eleven Swedish preschools (children aged 1-5 years), between October 2011 and February 2014 (Sundberg et al., 2015). Our main selection criterion of preschools was that the preschool staff had science as an articulated part of their practice. We visited the preschools on 5-12 occasions per preschool and made observations and video recordings of practice. The study has followed the ethical principles relating to basic individual protection requirements outlined by the Swedish Research Council (2011), regarding information, informed consent, right to withdraw from participation, confidentiality and use of data.

For the focus group discussions, we chose approximately half of the video material from each preschool, seeking episodes that we wanted the teachers to discuss. Such episodes included, based on our overall impression from our observations in that preschool, recurring strategies or surprising actions. For example, one of the chosen sequences shows children and teachers stopping by a drain to listen to the sound of small stones hitting the water surface. We chose this sequence since we had found that their lingering over children's discoveries was a recurring strategy for drawing attention to scientific phenomena.

Teams of three to five teachers participated in the discussions, as well as one or two researchers. The discussions lasted for between 40 minutes and two hours, and during 10 to 30 minutes of this time video sequences from that particular preschool were shown. The goal was that the teachers should discuss science in preschool, while researchers had a more peripheral role, mainly asking clarifying questions referring to what the video episode had shown, such as "What happened before, or afterwards?". The researchers also asked for general descriptions relating to the video episodes, such as "Is this how you usually work?". The discussions were video- or audio recorded and transcribed and the transcripts make up the material we have analysed.

Earlier we have presented dichotomies, opposite concept pairs, in light of gendered practices, epistemology, feminist critique and research on the nature of science. In this study we use the concepts pairs objective-subjective and logical-intuitive to operationalise "possible ways of knowing in science in preschool", generating analytical questions as well as categories from dictionary descriptions (Merriam Webster online n.d.) together with our empirical material (see Table 1). We have not posed any explicit question regarding objective, subjective, logical or intuitive during the teacher discussions of the video sequences.

Elaborating analytical questions connected to the concept pairs

For an initial sorting of the transcripts we needed analytical questions that grasped the meaning of the concept pairs objective- subjective and logical-intuitive. The dictionary speaks of objectivity as being independent of the individual while subjective is described as "modified or affected by personal views, experience, or background", as well as "lacking in reality or substance: illusory". Bearing this in mind while reading and re-reading the transcripts, we established that the analytical question connected to the objective-subjective pair concerns how to gain knowledge about the material world. In a similar way we established that the question connected to the logical-intuitive pair concerns how to reach explanations of scientific phenomena. This since "logical" can refer to formal reasoning based on "logic", i.e. on an inevitable series of facts, and "intuitive" refers to instinctive explanations without evident rational inference

Accordingly, the questions that guided our selection of transcript quotes were: Does the sequence concern how to gain knowledge about the material world or how to reach explanations of scientific phenomena? The analytical questions are: What appear as possible ways of gaining knowledge about the material world or of reaching explanations of scientific phenomena? (see Table 1)

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Table 1. Analytical tool showing research question, data, questions for selection and analysis of quotes, and the coding categories.

Research question	**Data**	**1. Selection of quotes**	**2. Analytical questions**	**Coding categories**
How does teachers' talk about science in preschool relate to possible ways of knowing?	Transcripts of video-stimulated group discussions with teachers	Does the sequence concern how to gain knowledge about the material world?	What appear as possible ways of gaining knowledge about the material world?	independent of the individual, noticing similarities/differences, working with experiments, observing, sense perception, working with material, whole-body perception, dramatising, depending on individual liking/interpretation, imagining
		Does the sequence concern how to reach explanations of scientific phenomena?	What appear as possible ways of reaching explanations of scientific phenomena?	explaining based on empirical facts, explaining based on theoretical facts, negotiating ideas, presenting and listening to each other's ideas, instinctive explanations

Formulating and recognising categories

The analysis of the transcripts resulted in ten categories related to the concepts objective-subjective (see Fig. 1) and five categories related to logical-intuitive (see Fig. 2). The procedure of finding the categories was as follows:

First we distinguished categories that were adjacent to the descriptions of the words objective, subjective, logical, and intuitive (Merriam Webster online n.d.). One example is the description regarding "objectivity", which includes "involving or deriving from sense perception or experience with actual objects, conditions, or phenomena". From this the categories *sense perception* and *working with material* originated. Another example is the description of "logical" which refers to the agreement with rules of logic, hence to the "interrelation or sequence of facts or events when seen as inevitable or predictable" From this we formed the category *explanations based on facts*.

In some cases we have found it necessary for a category to divide in two, or for new categories to break out from them. One such example is our reading through all the sequences coded with *sense perception* and finding that there were many references to experiencing with the whole body, as in the following sequence:

> The Spintop Preschool:
>
> Teacher L: I can feel this, this difference between the large and the small. The difference between, perhaps, going up the hill and rolling down it yourself – with your body – and just dropping something off the top of the big hill, and then being indoors and dropping something from this height (Teacher L measures a distance with her hand). To understand something from that context – that it is the same, somehow it is the same motion."

We consider exploring of this kind as a different, in the sense of more complex and less detached, way of perceiving the world compared to *sense perception*, which refers to perceiving with some of the five senses. When rolling down a hill you are the centre of the system in motion, instead of being an observer. This is interesting from the point of view of symbolic gender, as detachment and distance is associated with masculinity and science, while rolling down the hill oneself is more of a personal experience of a phenomena, thus line with feminine-coded, subjective ways of knowing. Our discussions led to *whole-body perception* breaking out from the *sense perception* category and our re-coding the transcripts according to this refinement.

Another example is the category *dramatising*, which broke out from the sequences coded as *whole-body perception* and/or *imagining*. One example of this is found in the transcripts from the Bird Preschool, where the teachers talk about how the children, in an activity including them moving to music, are able to distinguish that "swans are elegant, crows hop and jump, and the albatross sails majestically". These sequences include imagination, but are more specifically concerned with children who act and move in relation to some science content, which is why we consider *dramatising* as a category of its own.

A third example is the sequences within the early-on category *reasoning*, which covered a wide range, from examples of children only expressing their own thoughts when others listen, to children reaching a shared understanding through group discussions. We decided that it was not adequate to group these aspects under the same category and therefore we divided it in two: *presenting and listening to each other's ideas* and *negotiating ideas*.

It is important to mention that it is the teachers, through their talk in the group discussions, that outline what are activities concerning science content, while we researchers analyse their talk and draw it to different categories. A sequence being coded as, for instance, *dramatising* does not mean that a teacher has expressed this concept explicitly. Rather, the teachers' accounts have been coded as such if they express dramatising in a way that portrays it as a possible way of working with science content in preschool.

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Findings

A large share of the teachers' talk about science in preschool concerns gaining knowledge about and perceiving the material world, while relatively little is said that concerns how to reach explanations of phenomena in science. The findings are presented with examples from the empirical data, starting with two sections relating to RQ1, thus to possible ways of knowing; gaining knowledge about the material world and reaching explanations of phenomena. Both sections end with a summary of all the recognised categories. The third section relates to RQ2, how teachers handle the possible tensions between preschool practice and science practice, showing how the teachers' talk about science in preschool move between different categories.

Possible ways of gaining knowledge about the material world

Below is one example of a sequence found to regard how children are assumed to gain knowledge about the material world, in this case ice eggs. The category code is written in the right column.

The Ice Egg Preschool

Teacher A:	You could tell that they wanted to touch and feel the ice eggs.	*Sense perception*
Teacher B:	Yes, it is about the sensation as much as the experiment itself.	

This sequence indicates the complexity inherent in the categories. Both teachers talk about an experiment dealing with inhibiting ice from melting. When Teacher A watches the video she comments on the children showing a desire to experience the items at hand: the cold, slippery globes that slid on the plate they were on. Teacher B follows-up by putting the sensation in relation to the experiment, realising – and acknowledging – that this was an aspect as important as making hypotheses and performing the experiment. This indicates that the teachers considered both subjective experiences, which van be associated with feminine-coded preschool practice, and the experiment, which can be associated with traditional, masculine-coded science practice, as possible ways of gaining knowledge in the referred situation.

The categories can be closely intertwined in the preschool teachers' talk about activities concerning science content. This is exemplified in the sequence below, where teacher D talks about 2-year-old children gaining knowledge about magpies.

The Magpie Preschool

Teacher D:	We have shown the nest, taken it down, and **we have looked at the magpie (a plastic bird), seen its beak, tail and feet.** And we have talked about how the magpie flies and **we have been flying magpies, landing with our wings on our backs.** (…) We have talked about the magpie eating in the forest, and we have provided it with biscuits. (…) And then we ate from the ground and when it snowed it snowed on all the magpies.	*Observing* *Dramatising*

The teacher and children moved between observing the details of a plastic bird, talking about the birds' behavior and embodying this knowledge by acting as birds, paying attention to features that are specific to the bird, such as flying, landing, and eating from the ground. This is especially interesting from an early childhood perspective, as it indicates that 2-year-old children can communicate their knowing about science content in other ways than through verbal or written language. In the quote above, the teacher moves readily between referring to artificial magpies and to real magpies that can be seen close to the preschool, which indicates that she does not perceive imagination and reality as mutually exclusive in this situation.

In sum, our analysis of the transcripts gave the following categories: *independent of the individual, noticing similarities/differences, working with experiments, observing, sense perception, working with material, whole-body perception, dramatising, depending on individual liking/interpretation* and *imagining*. This means that all these categories appear as possible ways of working with science content, seeing all eleven preschools as a whole. In figure 1 we have made a tentative distribution of the categories, where the ones furthest to the left, in our analysis, are seen as more associated with the concept objective. Many of the categories have been located relatively close to this side since they connect to the dictionary description of "objective" as "involving or deriving from sense perception or experience with actual objects, conditions, or phenomena" (Merriam Webster online n.d.). We consider the category *imagining* to be highly dependent on the mind of the individual and not necessarily relating to an object that is tangible or visual for all, which is why we placed it closer to the right side in the figure.

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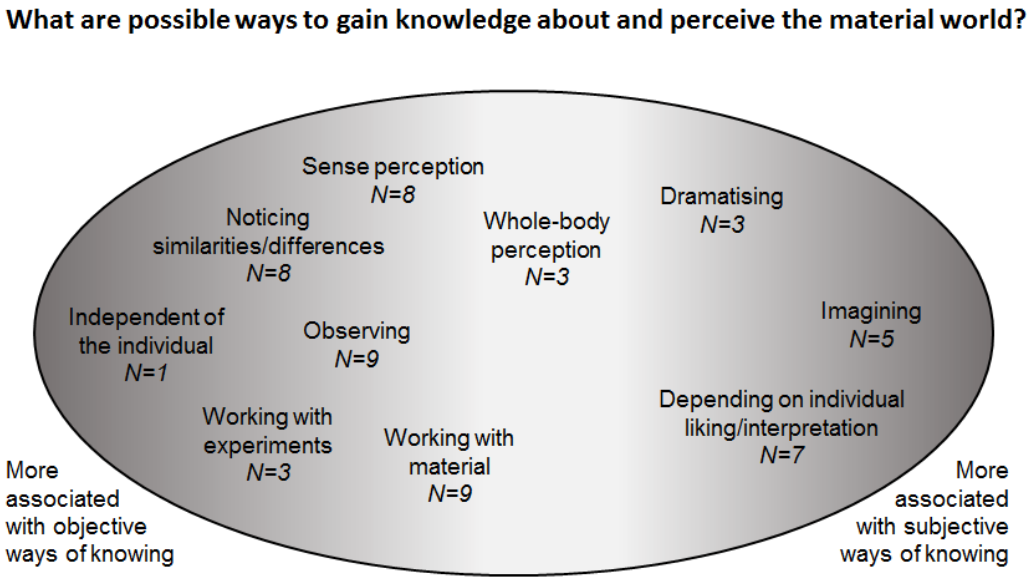

Fig. 1 The ten categories, representing possible ways of gain knowledge the material world, are distributed in relation to their associations with objective, left side, and subjective, right side, ways of gaining knowledge. N = number of preschools where the category appears (total number of preschools =11)

The locations of the categories, relative to the objective and subjective sides, should not be understood as final positions. Our analysis of the empirical data suggests that the categories can overlap, intertwine, and drift in relation to each other. However, we have found the illustration helpful to our approach in examining the meeting between gendered practices by analysing preschool teachers' talk in relation to gendered science-nonscience concept pairs. In light of the contrary gendered practices of preschool and science, it would, for example, have been an interesting finding if the empirical material mainly rendered categories associated with one of the two concepts.

One thing that is not obvious in the figure is the variety inherent in the categories, and particularly those placed in the middle of figure 1; *observing*, *sense perception* and *working with material*. We see that they cover large spans of possible ways of gaining knowledge about and perceiving the world. For example, the category *working with material* includes talk about children working with fair testing of different material as well as talk about a child who has been rolling a roll of tape for hours at home.

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Possible ways of reaching explanations to phenomena

In our material the category *instinctive explanations* concerns children's instant theories about scientific phenomena. According to the teachers these theories have a value in themselves and need not necessarily be challenged. The following sequence shows two examples of categories that regard how to reach explanations of phenomena. Teacher R refers to a video of her colleague and a small group of children gathering around an anthill, talking about what the anthill might look like on the inside, and why:

The Ant Preschool

Teacher R:	We have become better at this over the years (…) We have learnt not to give them these ready-made answers, but **instead to let children say what they think.** And there is no right or wrong. **We could say "OK, is that what you think?" or "Well, maybe…(giving another suggestion)" and then we continue discussing.**	*Instinctive explanations* *Negotiating ideas*

Here the teacher indicates that she and her colleagues strive to take a step back and let children tell their own ideas. She emphasises that the children's ideas will not be evaluated as "right or wrong". A resistance towards evaluating children's ideas as "right and wrong", and towards providing children with "readymade" answers, is present in several of the focus group discussions. This issue will be further discussed below. In some of the transcript sequences teachers tell about situations in practice where children's instinctive explanations remain unchallenged, but there are also example where teachers encourage children to communicate the ideas to each other and, as in this case, to negotiate different explanations.

Below we present two sequences that we have interpreted as being about explanations based on facts:

The Pond Preschool

Teacher J:	I am thinking about a child who found frog spawn in the pond. He was there and he touched it. We have been thinking a lot about whether there were frogs or toads (in the pond) and now we know the answer**. We read (in a book) that frogs lay their spawn in rows while toads lay their spawn in clumps, so now we know that there are frogs in the pond.**	*Explaining based on theoretical facts*

The Pine Preschool

Teacher K:	I am thinking about a child who today said: ”The pine tree is moving”. So we looked up. Yes, it was very windy (Teacher K shows by moving his arms). The pine trees were moving. They (the children) do reflect on experiences in nature. **It is windy now, so then the trees are moving and the needles too.** And they see that and they are attentive. Things that you do not think about yourself.	*Explaining based on empirical facts*

In the two sequences teachers tell about explanations that they have reached together with children, or that children have reached themselves. The first sequence, with the frog spawn, shows how finding and touching material led to an explanation based on theoretical facts from a book. The second sequence shows a teacher assuming that the child has drawn conclusions based on a line of empirical facts: it is windy – the tree is moving – the needles are moving, hence, the tree and the needles are moving because it is windy.

Non-verbal reasoning

The transcripts have opened our eyes to a delicate issue regarding our aim to map possible ways of reaching explanations of phenomena. In some of the preschools, with children aged 1-2 years especially, verbal communication is very limited. Before working with the empirical material we had more or less thought of written or verbal language as necessary in reasoning or explaining. However, the teacher discussions highlight how children communicate in other ways, and that the preschool teachers can recognise children’s non-verbal reasoning and their explaining based on empirical facts. One such example is found in the Magpie preschool, which is for children aged 1-2 years. The teachers give an example of a child who puts water in a bucket and turns it upside-down, knocking on the lid and lifting the bucket from the ground, looking surprised when the water flows out. The teachers discuss if the child might have expected the water to stay in a bucket-shaped form even after lifting the bucket. During that time of year, the children had worked a lot with making sand-cakes in the sandpit, which is why the teachers wonder if the child expected the water to behave in the same way as the sand. Along with other similar examples, this sequence has been coded as *explaining based on empirical facts.* The teachers were well-aware that they cannot know what children think, but they elaborate on children’s possible tacit reasoning based on facial expressions, gestures, and how children move around. The issue of non-verbal

explaining and reasoning partly lies beyond the scope of this paper, but we want to highlight it as an important aspect of describing what science for the youngest children can be.

In sum, our analysis of the transcripts gave the following categories related to reaching explanations: *explaining based on theoretical/empirical facts, negotiating ideas, presenting and listening to each other's ideas* and *instinctive explanations.* This means that all these categories appear as possible ways of working with science content, seeing all eleven preschools as a whole. In figure 2 we attempt to place the categories most dependent on a person's instinctive explanations to the right and on the other side those dependent on stringent reasoning based on facts, where inevitable sequences on factual-based arguments would be placed the furthest to the left.

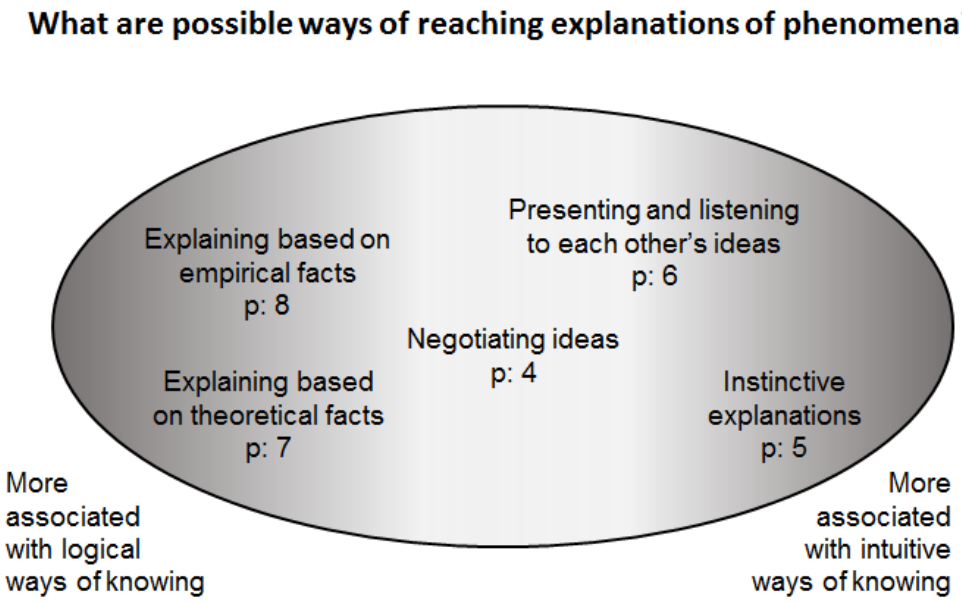

Fig. 2 The five categories, representing possible ways of reaching explanations of phenomena, are distributed in relation to their associations with logical, left side, and intuitive, right side, ways of reaching explanations. N = number of preschools where the category appears (total number of preschools =11)

Handling the possible tensions between preschool practice and science practice

Apart from the talk of preschool teachers covering several different categories, we have found transcript sequences in ten of the eleven preschools where the talk moves back-and-forth between different

categories, relative to the concepts objective-subjective or logical-intuitive. This goes for both short dialogue sequences and monologues. The sequence below shows an example of the latter.

The Mushroom preschool

Teacher C:	Something happened when we brought pencils and paper to the forest. Usually we paint when we come back, or the day after. When the children had brought pencil and paper **they discovered that there were no leaves on the trees**. They had not thought about that. Then some of them **decided to draw leaves anyway because it is prettier.** But they **made observations**.	*Observing,* *Depending on individual liking* *Observing*

Here Teacher C points out how bringing drawing material out to the forest caused a change in children's attention to what the trees actually looked like. She acknowledges that some of the children chose to, despite what they had observed, draw trees in a way that they found prettier, which we interpret as the children's own liking being a possible way of dealing with this activity. Thus the teacher's talk can be said to move from *observing* to *depending on individual liking*, and then, indicated by the teacher's final sentence, back to *observing*.

In the following example two teachers talk about changing variables when exploring how some items roll, or do not roll, down a hill. They also include children rolling down the hill themselves.

The Spintop Preschool

Teacher Q:	And why doesn't everything roll? The way you have imagined?	
Teacher R:	**And just this part about the incline varying, why does it roll faster? Why do you roll down a hill if you lay down?** We have big hills in our playground. We have thought about waiting a bit, we have some ideas, **one could lay down and roll (laughter) it will be velocity too somehow.** A lot of things come in…	*Noticing differences/similarities* *Whole-body perception*
Teacher Q:	I think about **different surfaces, friction**…The things we have right now are quite slippery. **What if we would put sandpaper on one of our strips?**	*Noticing differences/similarities* *Working with material*

Our interpretation is that the teachers' talk moves between *noticing differences/similarities*, which can be more associated with objective sides to knowing, to the more person-dependent category *whole-body perception*, and then back to *noticing differences/similarities*, this time through *working with material*. As mentioned earlier in regards to exploring rolling both with one's body and through material, this is interesting from the point of view of symbolic gender, and possible ways of knowing about a phenomenon. Here we see that the teachers tie both bodily, which is more associated with subjectivity, and material-based, which is more associated with objectivity, explorations of rolling to the idea of noticing differences and similarities.

The movements between categories imply that there is more than one possibility in specific issues or situations. Thus, these cases go against the assumed tension between objective and subjective sides of knowing, as the teachers' talk move between possibilities associated with subjective sides of knowing (e.g., individual liking and whole-body perception) and those associated with objective sides of knowing (e.g., observing and noticing differences).

Summarising the results of our analysis, there seems to be room for both sides of the concept pairs in the teachers' talk about science for preschool: for categories more associated with the feminine-coded concepts (subjective and intuitive) as well as with the masculine-coded concepts (objective and logical). Many categories were inferred from these four concepts, and recognised in the material. The wide range of possible ways of working with science content is based on material from all the preschools. However most of the preschools showed this variation internally.

Discussion

This study has its starting point in the expanded responsibilities for teaching science in preschool and the gendered practices of preschool and science. To learn more about the way preschool teachers combine science and preschool practice into *preschool science practice* is of great significance in understanding and developing science education in early childhood education. We find that the analytical questions connected to the concept pairs objective-subjective and logical-intuitive helped us to display a vast range of possibilities regarding how to gain knowledge about the material world – *independent of the individual, noticing similarities/differences, working with experiments, observing, sense perception, working with material, whole-body perception, dramatising, depending on individual liking/interpretation* and *imagining* (see Fig. 1) – and how to reach explanations of scientific phenomena – *explaining based on theoretical/empirical facts, negotiating ideas, presenting and listening to each other's ideas and instinctive explanations* (see Fig. 2). We have also captured how the talk of preschool teachers moves

readily between different possible ways of gaining knowledge about the world and reaching explanations of phenomena. Taking this into account, it seems reasonable to assume that the teachers in this study have found ways to combine science practice and preschool practice that goes against the presumed tensions between the practices (Harding 1986, Hirdman 2001).

The subjective sides of science practices

Our results show that categories associated with "subjective" and "intuitive" ways of knowing appear as possible parts of preschool activities concerning science content. We interpret this as stemming from the subject-oriented Bildung tradition of Swedish preschool (Thulin 2006), displayed in long traditions of child-centered pedagogy (Swedish National Agency of Education 2004). The current curriculum states that the children's needs and interests "should provide the foundation for shaping the environment and planning activities" (Swedish National Agency of Education 2011, p.12). We read this is as an opening for science activities to revolve around children's liking, imagination and instinctive explanations, which was the case in several of the preschools in this study**.** Including the subjective- and intuitive-related aspects in work with science is thus in line with the child-centredness outlined in the curriculum, emphasising the interests and needs of children, which in turn is intertwined with the caring traditions of preschool.

As mentioned earlier, most science curricula promote students' knowledge about the nature of science (NOS), which includes knowing that scientific knowledge production involve "human inference, imagination and creativity" (Abd-El-Khalick, Bell & Lederman, 1998, p. 418). However, Lederman (2007) shows that both teachers and students have difficulties grasping what NOS is, mainly due to lack of explicit instruction of NOS. When Akerson and co-workers explored NOS conceptions of young children, they showed that after different types of explicit instruction the children appeared to be better able to conceptualise scientific creativity and the relation between observation and inference (Akerson, Buck, Donnelly, Nargund-Joshi & Weiland 2011). Hence, the findings that more subjective and intuitive ways of working with science are possible in preschool, imply that preschools offer opportunities of starting explicit NOS discussions.

Deconstructing the hierarchy and mutual exclusiveness of subjective-objective and logical-intuitive

We argue that the findings of this study show examples of undermining dichotomies in terms of their inherent hierarchy and mutual exclusiveness. This since the teachers' talk covers several categories, related to both concepts in the pairs, and since their talk readily moves back-and-forth between categories. In contrast to what Lenz Taguchi (2000) formulates as preschool discourses being "squeezed in" between

discourses of masculinity and femininity, as in rational practices of documentation and observation in contrast to teachers as "designated mothers", our results display preschool science practices that deconstruct the mutual exclusiveness and instead make use of several categories connected to the concept pairs, where one concept is not valued over the other.

Drawing on Harding's (1986) three levels of gender – the structural and the symbolic level that has been mentioned earlier, and also the individual level which regards the gender identity of the individual – we interpret that the teachers' broad views mainly regard science practices as such, hence the symbolic level. However, we cannot say how the teachers associate this range of possibilities with the individual children, hence with gender on an individual level. Our analysis does not, for instance, cover whether teachers perceive any difference between boys and girls, with one being more logical or intuitive than the other, or if there is a perceived gender difference in how well suited for science they are. Still the teachers' comprehensive perceptions of possible preschool science practices suggest a view of all children being suited for science.

It is important to note that our sample of preschools is based on science being an articulated part of their practice. This condition might be an indicator of the teachers having relatively much content knowledge and confidence regarding science, which in turn could be crucial to daring, and knowing how to, work with science in a way that is not constrained by dichotomous conceptions.

Handling children's reasoning and explanations

The science learning responsibility is not generally perceived as problematic by the preschool teachers in this study. However one issue that sometimes causes tension is related to dealing with explanations of phenomena in science. In four of the eleven preschools some or all of the preschool teachers take a stand by talking about "holding back" and not interfering with children's own thoughts. Further there are teachers in five of the preschools who express resistance towards evaluating children's ideas as "right or wrong" or towards providing children with "readymade answers". Our understanding is that this is not to be read as teachers rejecting the idea of anything being more right than anything else, but rather that teachers want to focus on the process towards a conclusion instead of the conclusion itself. Further the statement "there is no right and wrong" could be interpreted as teachers positioning their practice away from perceptions of school science practices. Such perceptions can, as Sundberg and Ottander (2013) has shown, include ideas of the adult's authoritative transmission of knowledge to children. The tensions in the material brings forth the question of what it could mean to work with explanations and reasoning in a child-centred pedagogy, and specifically how to handle, and talk about, children's own ideas in relation to

the explanatory models offered by science. One issue rising from the empirical data relates to handling non-verbal ways of drawing conclusions about relationships in nature. This has been discussed in Klaar's and Öhman's (2012) study of a child exploring inclination and friction by climbing up and sliding down a hill. They focus on the relation between the toddler's actions and the consequences of these actions, and emphasise that toddlers' learning is physical and practical rather than verbal and conceptual. An additional approach is found in the case of New Zealand, where "working theories" is a central concept in the early childhood curriculum. Peters and Davis (2011) speak of working theories as children using their existing knowledge as a starting point from which to make meaning of the world. They argue for early childhood education to more often allow children to express theories without basing them on facts. Still, they point out the role of teachers in helping children to extend and refine their working theories.

With this in mind, we argue that there lies a great potential in highlighting children's own ideas about phenomena in science. By doing so, the children are made aware that there are different phenomena in the world and that one can attempt to draw conclusions about relationships in nature. However, the results indicate a need to further examine the teachers' interactions with children's reasoning, and when doing so, the categories presented in figure 2 could be advantageous to elaborate our ways of thinking and communicating about science for the youngest.

Science practices that include the youngest children

The aim of our study is to contribute knowledge about if and how teachers combine science learning goals with preschool practice, and to contribute more nuanced ways of communicating about science in preschool. We argue that our approach of exploring the concept pairs objective-subjective and logical-intuitive in relation to empirical data has contributed repertories for communicating about gaining knowledge about, and reaching explanations of, phenomena in science. Further the approach has helped us to see that teachers generally combine science learning goals with preschool practice in a way that does not cause tension, though in the case of dealing with children's explanation tensions where visible.

Taken as a whole, the goal of this paper is to contribute to the discussions of what science in preschool (children 1-5 years old) can be. With this comes the question of who science should be for. Harding (1991) poses an intriguing question in the title of her book *Whose Science? Whose Knowledge?*, in which she argues that science must be renewed in order to be for everyone, regardless of gender, race, class and culture. An additional social category to take into account here is age; what could science be when it comes to the youngest children? Though the field of research in early childhood science education is growing, studies of science learning of infant and toddlers (10-36 months) is lacking in literature. This

presumably since, in an international view, young children mostly spend their time in home environments, as pointed out by Sikder and Fleer (2015). In Sweden however, 48 per cent of 1-year-olds and 88 per cent of 2-year-olds are enrolled in preschool (Swedish National Agency for Education 2014), which makes it an interesting arena for studying institutionalised science learning for infants and toddlers. The results presented here indicate that "unconventional" and age-inclusive practices are taking place in Swedish preschools. The quotations included in this paper give insights into, for instance, how children approach science with their whole bodies – in drama, dancing and experiments where they themselves are at the centre of the system in motion. Further the issue of involving young children in science is salient in the teachers' talk about reasoning and explaining in non-verbal ways. We argue that these age-inclusive ways of approaching science make it easier for children to make science knowledge their own, but also that they call for a broadened communicative repertoire. Overall we argue that the results presented here have the potential to empower preschool teachers in shaping and describing their science practices, and paves the way for further development of science in preschool.

References

Abd-El-Khalick, F., Bell, R.L., & Lederman, N.G. (1998). The nature of science and instructional practice: making the unnatural natural. *Science Education*, *82*(4), 417-436.

Akerson, V.L., Buck, G.A., Donnelly, L.A., Nargund-Joshi, V., & Weiland, I.S. (2011). The importance of teaching and learning nature of science in the early childhood years. *Journal of Science Education and Technology*, *20*(5), 537-549.

Andersson, K., & Gullberg, A. (2014). What is science in preschool and what do teachers have to know to empower children? *Cultural Studies of Science Education, 9*(2), 275-296.

Archer, L, Dewitt, J., Osborne, J., Dillon, J., Willis, B., & Wing, B. (2012). "Balancing acts": Elementary school girls' negotiations of femininity, achievement and science. *Science Education, 96*(6), 967-989

Brotman, J.S., & Moore, F.M. (2008). Girls and science: a review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9): 971-1002.

Dewey, J. (1966). *Democracy and education: an introduction to the philosophy of education.* New York: The Free Press. (Original work published 1916)

Eshach, H., & Fried, M.N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology*, *14*(3), 315-336.

Fleer, M. (2009). Supporting scientific conceptual consciousness or learning in 'A Roundabout Way' in play-based contexts. *International Journal of Science Education, 31*(8), 1069-1089.

Garbett, D. (2003). Science education in early childhood teacher education: putting forward a case to enhance student teachers' confidence and competence. *Research in Science Education 33*: 467–481.

Gillberg, C. (2009). *Transformativa kunskapsprocesser för verksamhetsutveckling – en feministisk aktionsforskningsstudie i förskolan. [Transformative knowledge processes for organisational development – a feminist action research study in preschool]*. Växjö: Växjö University Press.

Harding, S. G. (1986). *The science question in feminism*. Ithaca: Cornell University Press.

Harding, S. G. (1991) *Whose science? Whose knowledge? Thinking from women's lives.* Ithaca: Cornell University Press.

Hildebrand, G. M. (1998). Disrupting hegemonic writing practices in school science: contesting the right way to write. *Journal of Research in Science Teaching*, *35*(4), 345-362.

Hirdman, Y. (2001). *Genus: Om det stabilas föränderliga former.* Lund: Liber.

Ideland, M. & Malmberg, C. (2014) 'Our common world' belongs to 'Us': constructions of otherness in education for sustainable development, *Critical Studies in Education*, *55*(3), 369-386,

Johnston, J. (2008). Emergent science. *Education in Science, 227.* http://www.ase.org.uk/journals/education-in-science/2008/04/227/ Accessed 9 December 2014.

Keller, E. F. (1985). *Reflections on gender and science*. New Haven, Conn.: Yale University Press.

Keller, E. F (1992). *Secrets of life, secrets of death: Essays on language, gender and science.* New York: Routledge.

Klaar, S. & Öhman, J. (2012). Action with friction: a transactional approach to toddlers' physical meaning making of natural phenomena and processes in preschool. *European Early Childhood Education Research Journal 20*(3): 439-454.

Lederman, N. G. (2007). Nature of science: past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook on research of science education.* (pp. 631-880). Mahwah: Lawrence Erlbaum Associates.

Lenz Taguchi, H. (2000). *Emancipation och motstånd: Dokumentation och kooperativa läroprocesser i förskolan.* Stockholm: HLS förlag.

Merriam Webster online. (n.d.).
Logic [Def 1a1,1c] http://www.merriam-webster.com/dictionary/logic. Accessed 5 June 2014.
Logical [Def 1a1,2] http://www.merriam-webster.com/dictionary/logical. Accessed 5 June 2014.

Objective [Def 1b,1d, 3a] http://www.merriam-webster.com/dictionary/objective. Accessed 5 June 2014.

Subjective [Def 3,4,5] http://www.merriam-webster.com/dictionary/subjective. Accessed 5 June 2014.

Intuition [Def 2] http://www.merriam-webster.com/dictionary/intuition. Accessed 5 June 2014.

Intuitive [Def 1] http://www.merriam-webster.com/dictionary/intuitive. Accessed 5 June 2014.

OECD (2006). *Starting Strong II: Early Childhood Edcuation and Care.* Paris: OECD Publishing.

Peters, S., & Davis, K. (2011). Fostering children's working theories: Pedagogic issues and dilemmas in New Zealand. *Early Years, 31,* 5-17.

Schiebinger, L. (1989). *The mind has no sex?* Cambridge, Mass.: Harvard University Press.

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

Siraj-Blatchford, J. (2001). Emergent science and technology in the early years. Paper presented at the XXIII World Congress of OMEP, Santiago, Chile. http://www.327matters.org/Docs/omepabs.pdf. Accessed 11 December 2014.

Siry, C. (2014). Towards multidimensional approaches to early childhood science education. *Cultural Studies of Science Education, 9*(2), 297-304.

Spektor-Levy, O., Baruch, Y. K., & Mevarech, Z. (2013) Science and scientific curiosity in pre-school - the teacher's point of view. *International Journal of Science Education, 35*(13), 2226-2253.

Statistics Sweden (2014). Women and men in Sweden: facts and figures. http://www.scb.se/statistik/_publikationer/le0201_2012A01_Br_X10Br1201eNg.pdf. Accessed 2 June 2015.

Sundberg, B. & Ottander, C. (2013). The conflict within the role: a longitudinal study of preschool student teachers' developing competence in and attitudes towards science teaching in relation to developing a professional role, *Journal of Early Childhood Teacher Education*, *34*(1): 80-94.

Sundberg, B., Areljung, S., Due, K., Ekström, K., Ottander, C., & Tellgren, B. (2015). Understanding preschool emergent science in a cultural historical context through Activity Theory. *European Early Childhood Education Research Journal*, Advance online publication. doi: 10.1080/1350293X.2014.978557

Swedish National Agency for Education. (2004). *Förskola i brytningstid - en nationell utvärdering av förskolan.* Stockholm: Fritzes. http://www.skolverket.se/publikationer?id=1272. Accessed 24 November 2014.

Swedish National Agency for Education. (2006). *Curriculum for the preschool Lpfö98.* Stockholm: Fritzes. http://www.skolverket.se/publikationer?id=1068. Accessed 1 September 2014.

Swedish National Agency for Education. (2011). *Curriculum for the preschool Lpfö98, revised 2010.* Stockholm: Fritzes. http://www.skolverket.se/publikationer?id=2704. Accessed 1 September 2014.

Swedish National Agency for Education. (2014). Barn och grupper i förskolan 15 oktober 2015, table 2B. http://www.skolverket.se/statistik-och-utvardering/statistik-i-tabeller/forskola/barn-och-grupper. Accessed 2 June 2015.

Swedish Research Council. 2011. *Good Research Practice*. Stockholm: Swedish Research Council.

Swedish Schools Inspectorate (2011). *Förskolans pedagogiska uppdrag. Rapport 2011:10.* http://www.skolinspektionen.se/Documents/publikationssok/granskningsrapporter/kvalitetsgranskningar/2011/forskolan-1/kvalgr-forsk-sammanfattning.pdf. Accessed 11 June 2015.

Tallberg Broman, I. (1991). *När arbetet var lönen.* Stockholm: Almqvist & Wiksell International.

Thulin, S. (2006). *Vad händer med lärandets objekt? En studie av hur lärare och barn i förskolan kommunicerar naturvetenskapliga fenomen [What happens to the object of learning? A study of how teachers and children in preschool communicate scientific phenomena]*. Växjö: Växjö University Press.

Thulin, Susanne (2011). *Lärares tal och barns nyfikenhet: Kommunikation om naturvetenskapliga innehåll i förskolan. [Teachers' talk and children's queries: communication about natural science in early childhood education]*. University of Gothenburg.

Traweek, S. (1992). *Beamtimes and lifetimes: The world of high energy physicists.* Boston: Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning, Meaning, and Identity.* Cambridge: Cambridge University Press.