Encountering Evolution

Children's Meaning-Making Processes in Collaborative Interactions

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ABSTRACT

This thesis explores preschool class children's meaning making processes when they encounter evolution. By adopting social semiotic and sociocultural perspectives on meaning making, three group-based tasks were designed. Video data from the activities were analysed using a multimodal approach. The analysis focuses on how the communicated science content affects the science focus of the tasks, how different materials function as semiotic resources and influence meaning making, and interactive aspects of doing science in the meaning-making processes.

The findings reveal that, by using the provided materials and their previous experiences, the children argue for different reasons for animal diversity and evolution. Throughout the tasks, a *child-centric view of life* emerged in a salient manner. This means that, apart from the science focus, the children also emphasise other aspects that they find important. The child-centric perspective is suggested to be a strength that enables children to engage in science activities.

The results show that the provided materials had three functions. Children use materials as *resources providing meaning*. This means that the children draw on the meaning potential of the materials, a process that is influenced by their previous experiences. Moreover, in interaction with peers, the materials also serve as *communicative* and *argumentative tools*. Thus, access to materials influences the children's meaning making and enables them to discuss evolution and "do science".

The findings also reveal an intimate relationship between task context and interaction. More scripted tasks convey more child–adult interaction (scaffolding) while less scripted tasks, during which children build on previous experiences instead of communicated science content, stimulates child–child interaction (mutual collaboration). In scaffolding interactions, a greater emphasis is placed on the science topic of the task due to guidance from the adult. Consequently, meanings made by children in more scripted tasks are more likely to be "scientifically correct". However, if the teacher or the adult steps back and allows the children to engage in mutual collaboration, they engage in multiple ways of doing science through evaluating, observing, describing and comparing.

Overall, the research reported in this thesis suggests that task contexts and materials have a great impact on children's meaning making and how science is done.

Keywords: Meaning-making processes, Science Education, Evolution, Multimodality, Collaborative Interaction, Exploratory studies.

ABSTRAKT

Den här avhandlingen utforskar förskolebarns meningsskapandeprocesser kring evolution. Tre gruppbaserade aktiviteter har designats. Videodata har analyserats utifrån ett multimodalt perspektiv på kommunikation. Analysen fokuserar på hur kommunicerade naturvetenskapliga beskrivningar av evolution påverkar aktiviteternas naturvetenskapliga fokus, materials funktion som semiotiska resurser och påverkan på meningsskapande och interaktiva aspekter av att göra naturvetenskap.

Avhandlingens resultat visar att barnen, genom att använda material och sina tidigare erfarenheter, för olika resonemang kring varför djur utvecklas och blir olika. Genomgående har barnens syn på världen en betydande roll för meningsskapandeprocessen. Det betyder att barnen, förutom att fokusera på det naturvetenskapliga innehållet i aktiviteterna, också lägger stor vikt vid andra aspekter som är viktiga för dem. Det barncentrerade perspektivet förslås vara en styrka som möjliggör för barn att delta i och engageras av naturvetenskapliga aktiviteter.

De material som barnen har tillgång till de i de olika aktiviteterna har tre funktioner. Barnen använder material som meningsgivande resurser, vilket betyder att barnen använder materialens meningspotential. Denna process påverkas av barnens tidigare erfarenheter. Vidare används materialen som kommunikativa- och argumentativa redskap i interaktion med andra. Tillgången till material påverkar således barnens meningsskapande och möjliggör att de kan diskutera evolution påverkar barnens naturvetenskapliga handlande.

Avhandlingens resultat visar på en nära relation mellan uppgifters kontext och interaktion. Mer styrda aktiviteter medför mer interaktion mellan barn och vuxna (scaffolding). Mindre styrda aktiviteter, där barnen bygger på sina tidigare erfarenheter, stimulerar istället interaktion mellan barnen (mutual collaboration). Som ett resultat av den vuxnes agerande, läggs det större vikt vid det naturvetenskapliga innehållet (evolution) i scaffolding-interaktioner. Följaktligen är de meningar som skapas i mer styrda aktiviteter mer i linje med naturvetenskapliga förklaringar till evolution. Samtidigt finns det ett samband mellan att den vuxne kliver åt sidan och att barnen kliver fram och gör naturvetenskapliga handlingar som att utvärdera, observera, beskriva och jämföra.

Sammanfattningsvis visar den här avhandlingen att uppgifters kontext och material har stor påverkan på barns meningsskapande och hur de gör naturvetenskap.

Acknowledgements

When I was interviewed for a doctoral student position in 2014, I said that I had never dreamt of being a pop star. Instead, I claimed that I had always dreamt of being a researcher. Well, partly that was a lie. I wanted to be a pop star *and* a researcher. However, even though I have given up the dream of being a professional singer, I persevered with the dream of becoming a researcher. Little did I suspect the hard work, blood, sweat, and tears it would take to achieve this dream.

I want to thank my three supervisors: Magnus Hultén, Karin Stolpe, and Konrad Schönborn. Magnus, thank you for questioning and challenging my ideas. Sometimes we have not had a shared common understanding of the semiotic resources at hand. As shown in the results of this thesis, previous experiences have a great impact on how meaning is made. In other words, we see different things and sometimes I don't even understand that I don't understand. Your great expertise and humble attitude towards the academy are a true inspiration.

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Mum and Dad, this thesis is about evolution. You are both extremely intelligent; thank you for those genes. This thesis is also about making meaning in situated contexts and how children make use of previous experiences as they encounter new topics. In my life, both of you have contributed to creating a context characterised by curiosity and discussion. Thank you for always encouraging me to follow my dreams and making me believe that I can accomplish anything if I only work hard enough.

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Viktor, you are my rock. You remind me that I'm not only an academic. Thank you for being you and for being my best friend, my best playmate, and my best discussion-partner. I will always be grateful for your support and for the way you have encouraged me to keep up and carry on *and* to let go, unplug from work, and just be in the moment.

My children, Linnea, Stina and Tyra. You are what matters. Era funderingar över livet och frågor om världen har haft stor påverkan på att jag velat förstå hur barn gör när de lär sig något nytt. Ni har velat höra berättelsen om hur djur egentligen blir olika, varför jag, Linnea och Stina har likadana krokiga lillfingrar, berättelser om kungarna förr i tiden, berättelsen om varför saker är som de är. Hade jag inte haft er, hade den här avhandlingen nog aldrig blivit till. Så, tack för att ni är precis så som ni är, och för att jag får vara er mamma och bonusmamma. Nu är jag inte längre en doktoranka ☺ utan en doktor, men inte en sådan som jobbar på sjukhus.

Tusen tack till alla barn och förskoleklasslärare som deltagit i den här studien.

Furthermore, I would like to say a few words about the cover of this book. The silhouettes were drawn by my daughter Linnea and her stepdad, Viktor. The cover captures three major aspects of this thesis: playfulness, multimodal communication, and evolution. The cover is a playful take on the classic image of the evolution of man. The animals portrayed are in turn Linnea's and Viktor's interpretation of the piloses, a fictitious species focused on in the thesis. Each image of the animals is based on clay models made by preschool class children in a task in which they modelled piloses that lived in a changed environment in the future.

Lastly, I would like to quote one of the wonderful children who participated in this study. This quote nicely sums up the whole process of writing a thesis:

> It's kind of fun to sit here and ponder. But it's
> quite hard too. My brain is cracking!

<div align="right">

Norrköping, 26 August 2019
Johanna Frejd

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List of Papers Included in the Thesis

The papers are referred to using roman numerals.

I   Frejd, J. (2018). "If It Lived Here, It Would Die." Children's Use of Materials as Semiotic Resources in Group Discussions About Evolution. *Journal of Research in Childhood Education*, *32*(3), 251–267.

II   Frejd, J. (2019). When Children Do Science: Collaborative Interactions in Preschoolers' Discussions About Animal Diversity. *Research in Science Education*, 1–22.

III Frejd, J. (re-submitted to *Research in Science Education*) Children's Meaning Making in Science During Interactive Read Aloud: The Example of Natural Selection.

IV Frejd, J., Stolpe, K., Hultén, M., & Schönborn, K. (submitted) Kneading a Pilose: What Meaning about Evolution do Children Transfer from a Storybook Read Aloud to a Modelling Task?

Children's Meaning Making in Science

This thesis is about children's meaning making about evolution[1] as they engage in group-based activities. The children studied in this thesis are six-year-olds who attend preschool class. Children in this age group encounter science in their everyday contexts, both at home and at school. Meaning making about science phenomena can arise in everyday contexts for children of this age.

A couple of years ago, my daughter, at the time five years old, called to me from the bathroom. When I entered, she was lying in the bathtub with water over her ears. "Listen mum," she said. She tapped with her finger on the side of the tub. "It sounds really loud!" I told her that it was not loud to me, not in my ears. "No, but that's because you're not in the water." What my daughter was doing was making meaning about a science phenomenon: sound. However, meaning making was not occurring in isolation. In the context of taking a bath, her action of tapping the tub became a resource for making meaning. Her tapping the tub and verbally explaining her experience became a way of communicating her meaning to me. Her meaning making was influenced by the objects around her, the tub and the water. In other words, the resources at hand had a great impact on the meanings made. She would not have discovered that tapping the tub sounds different depending on whether your ears are under the water or not, if she had not been lying deeply sunken into it.

A few years later, both my daughters, at the time six and nine years old, were walking next to each other on the way home from the park. It was a hot day, and they were both carrying water bottles in their hands. My older daughter, the girl who had been lying in the tub a few years earlier, all of a sudden placed her bottle next to her ear and wobbled her head from side to side so the water in the bottle moved back and forth. She walked like that for a while and then turned to her sister: "Listen, it sounds like it does in the tub." This short episode could be seen as though my girls were sharing a bodily experience of listening to the sound of a

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[1] In this thesis, when I write about evolution, I am referring to Darwinian evolution, unless stated otherwise. Furthermore, in this thesis the terms *theory of evolution* and *evolution* are used interchangeably.

water bottle. However, it could also be seen as an example of how the water bottle became a resource enabling her to interact and jointly make meaning with her sister about a phenomenon that she had first experienced several years previously.

The examples described above target sound, a physical phenomenon. Children also encounter science phenomena related to biology in their everyday contexts. For example, they feel their hearts racing when they run and hear birds singing in the spring. In my experience, one recurring biology-related topic that many children reflect upon is inherent resemblances. Children compare themselves to the people around them and describe similarities and differences. Inherent resemblances are consequences of evolution. Some inherent resemblances are easier for children to observe than others. For example, one child at a school where I worked said that "we were related" since we had the same hair colour. At the same time, children can express that the flowers in the yard are "the same" as those outside their houses, without describing these flowers as "related".

Children observe the world and make meaning of what they experience. Sometimes their experiences concern sound, and sometimes evolution-related topics, such as inheritance. In this thesis, meaning making about evolution is the focus. To set the scene, I begin by describing the theory of evolution from a scientific point of view, providing arguments for why evolution should be introduced to children, and presenting the preschool class practice. The last section of this chapter provides the rationale and aim of the thesis.

The Theory of Evolution from a Scientific Perspective

Many researchers turn to the ancient Greeks when describing the background to their research interest. However, in this thesis I turn to an Englishman. In 1859, Charles Darwin published his book *On the origin of species* (Darwin & Beer, 1996). The book is "a long argument" that describes how species evolve through reproduction, variation and selection. Today, we have knowledge about processes occurring at the micro level (e.g. mutations) and environmental effects (e.g. epigenetics). Still, much of what Darwin presented 150 years ago remains the baseline for how evolution is understood.

The starting point for the whole idea is that all life on earth is descended from a common ancestor (Darwin & Beer, 1996). Thus, all life is related. This means that humans not only share a common ancestor with other primates, but also with flowers and dinosaurs.

One cornerstone of evolution is the fact of *randomised genetic mutations*. Simply put, genetic mutation means that something happens within a gene, which makes an individual slightly different from the other individuals within a population. Mutations can be positive, negative, or neutral. If they aid survival, or at least do not kill the individual (cancer is a type of mutation that does not aid survival), and if they are heritable, over time mutations can result in an entirely different species (Carroll, 2006).

Another cornerstone of evolution is that there is *variation* among all the individuals within a population and that much of this variation is inherited (Mayr, 1982). For example, humans inherit eye colour and flowers inherit their number of petals. Variation and inheritance are easily spotted if we take a look at ourselves. Our appearances resemble those of other family members, but we are not identical. It is harder for us to observe variation among dandelions, but they are also different from one another.

Natural selection is another cornerstone within the theory of evolution. Even if mutations are random, survival is not (Carroll, 2006; Mayr, 1982). Individuals exhibiting features that give them an advantage compared to others are more likely to survive. Surviving makes them more likely to reproduce, or to reproduce at a higher rate than other individuals within the same species. This, in turn, can lead to that individual passing on its successful mutated gene.

Speciation occurs when genetic differences among two populations reach an extent to which individuals from the two populations cannot interbreed. At this point, the two populations are considered different species. Speciation can be a consequence of geographical separation. This means that a population finds itself in two different places that cannot easily mingle, and the two populations eventually adapt to their different habitats. Speciation can also occur within the same geographical location, if the variation within a population allows some individuals to colonise a new habitat (Nosil, 2012).

Talking about the evolution of species always means talking about evolution at a population level. This takes time. Thus, *time* is a major factor (Carroll, 2006; Stenlund, 2019) in evolution. More specifically, generation time is a primary component of evolution. Some species can go through many generations within a few hours – for example, some bacteria – while other species' generation time is far longer.

In this thesis, I primarily explore how children make meaning about two evolutionary concepts; namely, speciation and natural selection. Nevertheless, as explained above, evolution is not a series of mechanisms isolated from each other, but a result of several interacting mechanisms and circumstances.

Introducing Evolution

The theory of evolution is one of the foundations of modern science and biology education. Wagler (2012) proposes that:

> If we are to *fully* understand *anything* about *any* species, we must first know how it was produced (i.e., via biological evolution), how it has changed (i.e., via biological evolution), and how it is currently being changed (i.e., via biological evolution) (p. 275).

The description of evolution provided in the previous section might lead one to think that understanding evolution is trivial. However, an extensive body of research shows that children have difficulties understanding it (Berti, Barbetta, & Toneatti, 2017; Berti, Toneatti, & Rosati, 2010; Evans, 2000; Samarapungavan & Wiers, 1997). Concurrently, teachers seem to have difficulties teaching it (e.g. Prinou, Halkia, & Skordoulis, 2011)[2]. Some scholars argue that evolution should not be introduced earlier than third grade and that, when it is introduced, instruction should be intense: several days a week (Berti et al., 2017).

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[2] Difficulties in understanding evolution are common among pupils of all ages (e.g. Ferrari & Chi, 1998; Shtulman, 2006) and among adults (e.g. Nehm & Reilly, 2007; Spiegel, Evans, Gram, & Diamond, 2006). Thus, these difficulties are not restricted to children.

Traditionally, the theory of evolution has been introduced during the latter years of primary school or in high school. However, in some countries, including Sweden, evolution is included in the curriculum at primary level (Hultén, 2008). Some researchers (e.g. Shtulman, Neal, & Lindquist, 2016) and teachers are now probing the potential benefits of teaching the theory of evolution to younger children, even at preschool level. One argument is that experiences and activities that reflect evolutionary explanations provide children with a foundation of ideas to build upon as they progress in their education (Nadelson, Culp, Bunn, Burkhart, Shetlar, Nixon, & Waldron, 2009). In other words, an early encounter with scientific explanations of evolution might facilitate children's meaning making. Another argument for allowing children to encounter evolution at an early age is that they tend to be interested in "big questions", such as death, space, and life (see for example Gallas, 1995). Early on, children come across things that relate to evolution. For example, children might hear that they are "a copy of their father" or have "their mother's eyes", or discover that they have the same crooked finger as their sibling. In my view, there is no need to avoid talking about big questions with children. However, exploring *how* children encounter big questions, such as evolution, can provide insight into how these types of topics can be introduced.

Preschool Class – between Preschool and School

All the children participating in this study attend a school level called preschool class. In Sweden, children begin preschool class during the year in which they become six years old. Preschool class follows preschool and takes place during the year before children begin first grade.

The Swedish preschool class has been described as an "in-between class", between preschool and primary school (Lago, 2014). It is characterised by the preschool's play-based practice and richness of play-based schooling materials. For example, in preschool class classrooms, children have access to picture books and construction materials (e.g. Lego). Furthermore, preschool class classrooms often consist of a set of several smaller rooms or are furnished in a way that enables different types of activities. For example, Lago (2014) describes how the preschool classes she studied had open surfaces intended for both play and "rug time" activities. In addition, there are also areas intended for playing house and

construction play. However, preschool class classrooms also contain materials that are common in primary school, such as alphabet cards on the walls, worksheets and whiteboards.

Since 2018, preschool class has been part of the compulsory educational system (Utbildningsutskottet, 2017)[3]. However, reading the *Curriculum for the compulsory school, preschool class and school-age educare* (Skolverket, 2018) exposes one major difference between preschool class and primary school; namely, that children in preschool class *should be given conditions* to develop their abilities in various subjects. Thus, like preschool practice, there are no specific goals relating to *the extent to which* children need to learn. In addition, the preschool class is characterised by learning through play and creative activities are foundational to this practice (Skolverket, 2018). Consequently, teachers in preschool class need to playfully seek ways to build upon children's knowledge (Botö, 2018).

In all early childhood education, including preschool class, teachers should provide experiences that enable children to explore different scientific phenomena (Siraj-Blatchford, 2001). However, there is very little knowledge about how science education is actually carried out in preschool class. Elm Fristorp (2012) has studied preschool class children's meaning making in science as part of her thesis. She found that experiments and other "investigating" activities enabled children to explore science topics freely. Nevertheless, Elm Fristorp concludes that it is primarily the teacher's interest that guides the education. The preschool class curriculum (Skolverket, 2018) also provides some insight into what science education in preschool class might be. For instance, the curriculum suggests sorting and grouping plants and animals as well as learning the names of common species. Furthermore, aspects of the science discipline related to the nature of science are highlighted. For example, all children should have the opportunity to explore, investigate, ask questions, and talk about science.

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[3] The data upon which this thesis builds was collected between 2015 and 2017, when the preschool class was still a voluntary school form. However, the great majority of Swedish six-year-old children attended preschool class during these years. In 2015, 95–96% of six-year-olds attended preschool class (Skolverket, 2017). In 2017, it was 97.1% (Skolverket, 2019).

In conclusion, the preschool class can be understood as a two-fold practice, both regarding its character as an "in-between class", combining playfulness and schooling, and in relation to science education, combining subject knowledge and science practices such as observations, systematic investigations, asking questions, and forming hypotheses. The combination of play and schooling makes preschool class an interesting practice to study in relation to exploring children's encounters with science and developing new, exploratory ways of introducing science topics.

Rationale and Research Aim

Research on how children of approximately the same ages as Swedish preschool class children understand the theory of evolution and concepts related to evolution has shown that it is notoriously difficult to learn; and to teach. However, children like to explore big questions, and evolution is one such question. Therefore, there is a need to find new ways to introduce aspects of evolution to children.

The Swedish preschool class combines the preschool tradition of playfulness and richness of material resources with the traditions of schooling from primary school. The preschool class is therefore an interesting place to develop new exploratory ways to introduce evolution. That is, the characteristics of preschool class of being "in between" preschool and primary school allows new ways of combining play and schooling to teach evolution.

As mentioned above, there is some knowledge about how children *understand* evolution. Yet, there is little knowledge about how they *encounter* meaning making about evolution. That is, previous studies have focused on what children know and what they have learnt by taking part in educational activities. In this thesis, I aim to investigate the meaning-making processes that occur when children *engage* in activities. Here, the richness of playful materials in the preschool class is seen as a possible strength, making the use of different resources in meaning making an interesting field to study.

By analysing the process, and not merely the learning outcomes, this thesis can provide insight into crucial aspects of how teachers can provide preschool class children with conditions conducive to engaging in meaning making in science. Furthermore, by researching preschool class

children's meaning making when they encounter evolution, this thesis has the potential to contribute to how teachers in early childhood education can work with science in general and the area of evolution in particular.

The overarching aim of this thesis is to explore preschool class children's meaning-making processes when they encounter evolution. More specifically, the thesis aims to investigate how different resources, such as teaching materials, task contexts and interactions, influence children's meaning making about evolution.

Structure of the Thesis

This is a compilation thesis, consisting of four papers and a comprehensive summary. The four papers are listed below. Throughout the thesis, the papers are referred to using roman numerals.

Paper I   "If It Lived Here, It Would Die." Children's Use of Materials as Semiotic Resources in Group Discussions about Evolution.

Paper II   When Children Do Science: Collaborative Interactions in Preschoolers' Discussions about Animal Diversity.

Paper III   Children's Meaning Making in Science During Interactive Read Aloud: The Example of Natural Selection.

Paper IV   Kneading a Pilose: What Meaning about Evolution do Children Transfer from a Storybook Read Aloud to a Modelling Task?

Each paper has its own aims and research questions, which all contribute new knowledge. However, to explore how task contexts influence meaning making, I have chosen to re-analyse some data examples using the analytical lenses employed in Papers I–IV.

After this introductory chapter, Chapter 2 provides a literature review of what is known about children and evolution. Chapters 3 and 4 outline the theoretical lenses and methodology used in the analysis. Chapter 5 presents a summary of the papers constituting the thesis while Chapter 6 outlines and discusses the findings of the thesis as a whole. Chapter 7 provides a general discussion and Chapter 8 presents implications for

practice and research. In the final chapter, the thesis is summarised in Swedish.

Evolution and Early Childhood Education

This literature review draws upon research on evolution and early childhood education. Roughly speaking, researchers focus either on children's conceptual understanding or on how they can be taught evolution. In the following sections, I outline the findings of previous research related to these two perspectives. More specifically, the first section describes what is already known about children's understandings and common misunderstandings of evolution from a conceptual understanding perspective, and how understanding evolution seems to have a cultural dimension. The research presented on children's understandings of evolution includes children aged 5–12 years.

Next, different ways of teaching the theory of evolution in early childhood education are described. Some of this literature includes children of preschool age, other studies focus on children during the early years of primary school. This is followed by a section that outlines the findings from studies using one teaching tool, storybooks, to teach evolution to children in preschool and the early years of primary school. The chapter concludes with my thoughts on this body of research.

Children's Understanding of Evolutionary Concepts

The theory of evolution is difficult to understand[4]. A substantial amount of research reveals various difficulties. Within the research field that investigates children's conceptual understanding of evolution, researchers use a specific terminology to describe so-called "misconceptions" or "misunderstandings". To aid the reading of the following literature review, this section begins with a short description of the most common alternative ways of reasoning regarding evolution and the origin of species reported in the literature.

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[4] The terminology used in this section regarding "understanding", "misconceptions" and "misunderstanding" evolution reflects the theoretical perspectives used by researchers focusing on conceptual understanding.

Alternative Reasoning and Explanations of Evolution

The literature reports many ways of talking about evolution and the origin of species that are not scientifically "correct". One reported alternative reasoning is that animals have immutable features. This type of reasoning is called *essentialist reasoning*. From an essentialist perspective, a cat is a cat, because it is a cat. In addition, all cats look and acts in certain ways. These observable features make up what "a cat" is, and what a cat has always been. When holding essentialist beliefs, there is a risk that variation within species is left out and, in turn, species are not believed to evolve (Samarapungavan & Wiers, 1997).

Another alternative way of reasoning is that evolution is goal oriented, or that there is a "higher meaning" to it. However, there is not. Instead, evolution is a consequence of randomised mutations, and an inherited biological variation that is exposed to natural selection. Randomised mutations are not goal oriented; they are random. Talking about a higher meaning to evolution is called *teleological reasoning* (Legare, Opfer, Busch, & Shtulman, 2018; see also references in Sánchez Tapia, Krajcik, & Reiser, 2018). According to Emmons, Lees, and Kelemen (2017), teleological reasoning can promote the idea that a species being adapted to its habitat is a consequence of "purposeful events that uniformly transform individual species members in response to need" (p. 322). The problem with this is that evolution is believed to happen at the individual level, not at the population level. Some scholars argue that the very concepts of "adaptation" and "population" have everyday meanings. In turn, when using the same words to describe evolutionary mechanisms, these concepts might imply agency, striving, and purpose, which in turn can lead to teleological reasoning (Moore et al., 2002; see also Sinatra, Brem, & Evans, 2008; Smith, 2010).

Teleological reasoning can be compared to *Lamarckian* explanations of evolution, in which animals are believed to evolve as a result of using or not using a particular body part in a certain way. The most common example is that giraffes are explained to have long necks as a result of stretching their necks to reach leaves.

Creationist reasoning is also commonly described in the conceptual understanding literature targeting evolution and the origin of species (e.g. Evans, 2000). Talking about the origin of species in a creationist way means that one believes that a god has created all species. It is worth

noting that, from a scientific point of view, creationist reasoning is not a misunderstanding of evolution. Instead, creationist ideas reject evolution, because if a creator has put a species on earth, there has been no development.

Children's Alternative Reasoning and Explanations of Evolution

Over the last few decades, several studies have investigated how primary school students understand speciation and the origin of species. However, the findings of these studies are somewhat conflicting. Samarapungavan and Wiers (1997) revealed that 9-year-olds and 12-year-olds tended to believe that animals have immutable features or "essences" (i.e. essentialist reasoning). However, Evans (2000) found that many children (aged 5–12 years) expressed creationist ideas when asked about the origin of species. Furthermore, children who acknowledged that species develop talked about this in a way that was more related to Lamarckian explanations than the Darwinian theory of evolution. Some children who expressed creationist ideas about the origin of species also demonstrated teleological reasoning, if they drew on any explanations for development at all.

Creationist ideas were also common in a study by Berti et al. (2010). They interviewed both children who had undergone formal education and children without formal education. Their analysis revealed significant differences between the two groups' explanations of the origin of species. Children without formal instruction expressed creationist conceptions, whereas children who had been taught that animals have evolved from other animals revealed a so-called "mixed conceptual framework", mentioning both creation and evolution. Thus, creationist ideas did not disappear as a result of instruction. Still, Berti et al. (2010) concluded that their results highlighted "the role of instruction and cultural mediation in the development of children's conceptions of the origin of species" (p. 528).

In a more recent study, Berti et al. (2017) examined how an intervention affected children's (aged 8 years) understanding of the origin of species. The children were interviewed before and after participating in ten lessons concerning evolutionary concepts such as mutations, within-species variation, and natural selection. The lessons were designed by the

researchers and the children's teacher and comprised activities such as drawing, reading informational texts, answering closed and open questions, and written and oral tests. The children were also taught about the evolution of several types of animals, such as fish, mammals, and birds.

Going into the intervention, many children showed a "no conceptions pattern". This meant that they gave "don't know" answers to most questions during the pre-interview. After the intervention, both creationist and "don't know" answers decreased. Instead, most students provided evolutionary answers to the questions. Nevertheless, Berti et al. (2017) concluded that the students had learned about evolution in a fragmented manner, which manifested in naïve or primitive evolutionary answers.

In summary, the research describing children's understanding of evolution and the origin of species suggests that children do not explain development in a scientifically correct way before they have been taught evolution. However, this is not surprising. Even if children observe similarities and differences among species in their everyday lives, knowledge about evolutionary mechanisms – for example, how this variation came to exist – is not something that is immediately apparent. Furthermore, studies of children's understanding of evolution show that many children who do acknowledge that species develop talk about it in a way that can be described as teleological or Lamarckian. Again, this is not very surprising. These types of reasoning are common in descriptions of evolution and the origin of species among much older students as well (Ferrari & Chi, 1998). Some scholars (Legare, Lane, & Evans, 2013) suggest that teleological and Lamarckian reasoning seem to be intuitive. Nevertheless, these forms of reasoning could also be a result of the fact that humans tend to describe many things as events or narratives (Bruner, 1991).

A Cultural Dimension to Understanding Evolution

Culture becomes relevant when talking about science education and encountering the theory of evolution among young children. In the pre-test in Berti et al.'s (2017) study, fewer creationist conceptions were reported than in previous studies by Berti et al. (2010) and Evans (2000). This variation in the range of creationist conceptions is explained as a result of different levels of exposure to religious teaching both across and

within countries (Berti et al., 2017). This finding reinforces the fact that understanding evolution has a cultural dimension.

The cultural aspect in reasoning about evolution is targeted in a study by Sánchez Tapia et al. (2018). In a project implementing a new curriculum for teaching evolution theory in Mexico, they explored Nahua students' teleological reasoning. Their aim was to gain insight into Nahua culture in order to contextualise the curriculum.

The participating children lived in a community that relies on natural resources to make a living. Families grow crops and keep animals near their houses. Moreover, there is a view that the Earth takes care of them, providing them with what they need, and in turn the people show gratitude to the Earth. By re-designing the teaching of evolution and making it more culturally relevant for the students, the project led to students becoming engaged. Sánchez Tapia et al. (2018) stress that learning science in "culturally relevant ways supports the learning of challenging biology concepts" (p. 348).

If preschool class is acknowledged as a culture that differs from primary school and elementary school culture, there might be alternative ways of introducing the theory of evolution that do not necessarily mean "teaching evolution intensively, several days a week" (Berti et al., 2017, p. 231). In this regard, a combination of formal instruction, modelling, and drawing (Nadelson et al., 2009) have been studied and proposed as fruitful methods for introducing evolution. The following section will further describe different approaches to introducing evolution to children.

Ways of Teaching Evolution to Children

There are several research programmes and studies aiming to develop curricula and activities for teaching evolution to children in effective ways. As mentioned above, Nadelson et al. (2009) have developed standardised lessons, including instruction and hands-on activities, to teach evolutionary concepts to preschoolers and second graders. Findings from their study show that children are capable of understanding and learning simplified versions of the concepts of adaptation and speciation.

Herrmann, French, DeHart, and Rosengren (2013) argue that children who accept that dramatic within-lifespan change is caused by biological mechanisms more "easily grasp that variation within species is caused by biological mechanisms, and that this, over time, can lead to

evolution" (Herrmann et al., 2013, p. 204). Therefore, Herrmann et al. have explored how knowledge of metamorphosis influences children's (aged 3, 4 and 7 years) reasoning about biological change. Their findings show that, even if children accepted the dramatic change within caterpillars when they observed this change first-hand, they did not generalise this knowledge to other species, such as tadpoles turning into frogs. Nevertheless, Hermann et al. suggest that children should be provided with first-hand observations of within-lifespan change when learning about within-species variation, one of the cornerstones of evolution. However, providing first-hand experience of the evolution of species is difficult, even though the evolution of bacteria can be observed in a test tube (Bohlin, 2017). Still, providing opportunities to observe evolution is exactly what Horwitz, McIntyre, Lord, O'Dwyer, and Staudt (2013) have aimed to do. They have created an interactive, computer-based "virtual laboratory" in which ten-year-old students can experiment with systems, both plant-based and animal-based, that evolve over short time periods. For example, the children can grow virtual plants, which are then suppressed by environmental changes. The authors claim that the virtual laboratory improves children's understanding of natural selection.

In a study by Campos and Sá-Pinto (2013), children (grade K-4[5]) explored evolutionary concepts in contexts assumed to be familiar and relevant to the children. The authors describe five activities that simulate evolution presented as games, framed within short stories. For example, natural selection was simulated through telling a story about animals in the woods. As predators, the children "hunted down" prey, meaning focusing on smarties in a jar mostly filled with pebbles with some smarties amongst them. In the next generation of animals (smarties), the remaining smarties "reproduced" – generating two smarties of the same colour. Over time, one colour of smarties became dominant. Campos and Sá-Pinto suggest that the children were able to understand topics such as genetic drift and natural selection through this kind of playful activity.

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[5] In the American school system, "K" stands for Kindergarten. Children attend kindergarten when they are about five years old.

Using Storybooks to Introduce Evolution

Storybooks have been used as pedagogical tools in many school subjects for a long time (Teale, 2003)[6]. Over the last few years, several studies have investigated what aspects of evolution, and to what extent, children at preschool and primary-school level can learn by listening to or reading storybooks. Browning and Hohenstein (2015) state that one of the benefits of storybooks is that they have an explicit chronology that "helps children to link events with ease and understand causes and consequences of events more clearly thus encouraging understanding of the more specific aspects of a story, or theory" (p. 14).

Legare et al. (2013) have revealed that needs-based narratives, where the evolution of traits is described in terms of responding to animals' basic need for survival, affects children's learning of evolutionary concepts in a positive way. One could argue that needs-based explanations do bear similarities to teleological reasoning. For example, if we describe that a cat needs to have sharp teeth in order to kill a bird, it seems likely that a child might think that cats kills birds, therefore they have sharp teeth. However, what Legare et al. (2013) mean is that all living things have a set of features that "serves an organism's intrinsic needs, its ability to survive" (p. 187). The authors claim that purpose-based reasoning (i.e. teleological reasoning) is intuitive, and needs-based explanations for evolution might therefore give children an "understanding of purpose without impeding their understanding of natural law" (p. 187).

A research group at the *Child Cognition Lab* has conducted several studies aiming to develop pedagogical materials to teach evolution to young children. In two studies (Emmons, Smith, & Kelemen, 2016; Kelemen, Emmons, Seston Schillaci, & Ganea, 2014), children were taught evolution through listening to a story called *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017). This storybook was custom made by the research team to help children acquire "a

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[6] In relation to science education, storybooks have been used to teach many science topics to children in addition to evolution. For example, light and colours (Leung, 2008), magnetism (Kalogiannakis, Nirgianaki, & Papadakis, 2018) and earthworms (Varelas, Pieper, Arsenault, Pappas, & Keblawe-Shamah, 2014).

complete and cohesive understanding of adaptation without holding any misconceptions" (Emmons et al., 2016, p. 1207)[7]. The book is defined as a factual narrative picture storybook (Emmons et al., 2017), and in this thesis, this book is from now on referred to as "the storybook" or "the book".

The storybook describes the evolution of a foraging trait, a skinny trunk, among a fictional species called the piloses. This skinny trunk enables the piloses to reach milli bugs, the animals that form their primary food source, which, after a climate change, have retreated into narrow tunnels below ground[8].

After they had listened to the story, the children's understandings were tested by an experimenter who conducted clinical interviews. The results from the first two studies using the book (Emmons et al., 2016; Kelemen et al., 2014) show that children as young as five years old can develop a simplified understanding of evolution when this information is provided through a narrative. These results have been confirmed by Shtulman et al. (2016).

Emmons et al. (2017) conducted another study to examine the storybook's impacts on children's understanding of evolution. However, in this study, the researchers added questions about camouflage-related traits in order to investigate 6-year-old and 8-year-old children's ability to make a far-reaching transfer of their knowledge. The findings showed that at least the children in the older age group were able to achieve this far-reaching transfer.

In conclusion, many studies have shown that children are capable of learning about the theory of evolution through listening to storybooks.

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[7] In addition to this book, the researchers have also developed lesson plans and assessments that can be used by teachers. How to use the materials is described in detail. The researchers have also produced a guide for how to respond to children's misconceptions during discussions of the book. In addition, teachers are encouraged to study a "pointing guide" before reading the book.

[8] Please see: "The Storybook *How the Piloses Evolved Skinny Noses*" in Chapter 4 for a more thorough description of the book's content.

Developing Methods to Introduce Evolution in Preschool Class

At the beginning of this chapter, I stated that research on evolution and early childhood education in general focuses *either* on children's conceptual understanding, *or* on how they can be taught evolution. In this section, I briefly reflect upon the previous research within these fields.

The research targeting children's understanding of evolution (Berti et al., 2017; Berti et al., 2010; Evans, 2000; Samarapungavan & Wiers, 1997), and much of the research on using storybooks to introduce evolution (Emmons et al., 2017; Emmons et al., 2016; Kelemen et al., 2014; Legare et al., 2013; Shtulman et al., 2016), share the common view that children's learning is a result of instruction. That is, instruction, whether expressed through a storybook or lessons led by a teacher, is seen as a way of transferring knowledge from the storybook or the teacher to the child. Furthermore, these studies are highly scripted. That is, data has been collected during 1:1 interviews that aim to capture children's understandings of aspects of evolution. In addition, these studies have a clear focus on children's verbal expressions. However, if researchers only focus on verbal communication, as most studies within the conceptual understanding tradition do, and do not acknowledge children's non-verbal communication, potential aspects of children's meaning making in science become invisible (Britsch, 2019; Elm Fristorp, 2012).

The other cohort of research, namely many of the studies focusing on engaging students in learning through activities, has shown that children can gain a simplified understanding of natural selection through such activities as games (Campos & Sá-Pinto, 2013) and virtual laboratories (Horwitz et al., 2013). These results are in line with findings from other researchers focusing on children's meaning making in science. For example, Caiman (2015) has shown that science is an emergent process taking place within activities, and that children's "bodily actions" serve to both explore and illustrate meaning making. Furthermore, Elm Fristorp (2012) has shown that children, individually and together with others, engage in meaning making.

This thesis places itself within the field of research that aims to find new ways of introducing evolution and engaging children in meaning making about it. The theoretical approach chosen to accomplish this is further described in Chapter 3.

Meaning Making as a Theoretical Framework

This chapter outlines the theoretical framework of the thesis. The chapter begins with a general description of the sociocultural and social semiotic perspectives on meaning making. Next, I describe three theoretical lenses; namely: science as a focus for meaning making, materials functioning as semiotic resources, and interactive aspects of meaning making, in more detail.

I focus on meaning making as process, and how this process is carried out in group-based activities. I adopt the view of meaning making as what happens when ideas, thoughts and concepts are processed, both individually and in interaction with others (Mortimer & Scott, 2003).

Doing Science

A social semiotic perspective on meaning making assumes that meaning is *made* (Lemke, 1990). Along the same lines of viewing meaning as made, science can be seen as something that is *done*. That is, science is a human activity that is constructed through and during interactions between people and materials (Ash, 2004; Siry, Ziegler, & Max, 2012). From this perspective, meaning in science emerges from "doing" science (Siry et al., 2012). This means that, while doing science, for example by explaining, describing, and making observations, science is "talked" into being (Ash, 2004; Gallas, 1995; Lemke, 1990).

Siry et al. (2012) define doing science as a collaborative act and a social process whereby children's understandings are generated and expressed in interaction. Siry et al. focus on the interactional processes that occur when children engage in scientific inquiry. Lemke (1990) contributes with a definition of doing science in discussions[9]. According to

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[9] Lemke also uses the phrase "talking science" interchangeably with "doing science".

Lemke, doing science includes several acts[10], for example observing, describing, comparing, discussing, questioning, challenging, and evaluating (cf. Jiménez-Aleixandre, Bugallo Rodríguez, & Duschl, 2000).

Communication is Multimodal

Meaning is made, distributed, received and remade through several modalities (Jewitt, 2011). A mode is a resource that we use to communicate, for example, our voice, a gesture, a gaze and so on. Viewing communication as multimodal thus means acknowledging that several modes are involved when we communicate. Lemke says:

> In face-to-face communication, we not only utter sound-streams, but we dance with one another: we move our bodies, from our eye-gaze and eye-blinks to our arm and hand movements, our body postures, our leanings toward and away from one another, in a complex interactional synchrony of which the soundstreams we make are an integral part. (Lemke, 1993, p. 4)

This vivid quote sheds light on the idea that what is expressed in any mode is always intertwined with what is expressed in other modes in an interaction within a particular context (Goodwin, 2000; Jewitt, 2011). In that sense, communication can be viewed as though we are all performing in a one-man-band, not on solo instruments. The different instruments and their tones together create the song, or meaning.

Regarding multimodal communication in science education, Taylor (2014) has shown that children make meaning "in between and around words, postures and gestures" (p. 408). For example, a child in Taylor's study illustrated the function of the lungs through bodily actions instead of words. Taylor concluded that there "is an absence of language but not an absence of meaning" (p. 415). Similarly, Samuelsson (2018) suggests that children exploring the physical concept of spinning "reason *with*

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[10] Johnston (2009) uses the term "scientific skills" to describe similar acts of doing science. Johnston suggests that questioning by adults, such as researchers or teachers, scaffold children from observing to demonstrating other scientific skills, such as predicting, explaining, and interpreting.

their bodies as an integral tool in their explanations" (p. 100, italics in original).

In relation to the use of gestures, Goodwin (2007) has shown that they are coupled with the environment. That is, gestures are linked to the context in the sense that they might only be understood when the context is considered. Context is considered to include not only the physical environment, but also prior talk and actions, for example (Goodwin, 2007).

In this thesis, I view multimodality as valuable in order to explore how different modes are used in social practices within activities and how they interact with each other. This means that I focus, for example, on what a gesture *does* – that is, its function – rather than investigating the actual gesture itself (Ivarsson, Linderoth, & Säljö, 2011).

Acknowledging communication as multimodal enables a more detailed analysis of the meaning-making processes occurring in the data material that forms the basis for this study. Consequently, a multimodal perspective on communication makes visible other aspects of meaning making about evolution, rather than merely the verbal.

Three Theoretical Lenses to Study Meaning Making

The following sections more thoroughly describe the three theoretical lenses I have used to study meaning making as a continuous process carried out through multimodal interaction: The science focus, materials functioning as semiotic resources, and interaction. I chose these theoretical lenses because studying meaning-making processes about evolution in small groups requires studying interactions and how meaning emerges in interaction through the use of semiotic resources.

Meaning Making with a Science Focus

Meaning making is always about something. That is, meaning making has a focus or a topic. I use the term *meaning* to define an idea or a message that concerns the topic in focus (evolution) and concepts within this topic (e.g. variation, heredity, and natural selection). The use of the term meaning highlights that the focus of the meaning making does not necessarily reflect a scientific (i.e. "correct") use of concepts related to evolution. The meanings of concepts are thus seen as socially constructed (cf. Tang, 2011). In addition, the meanings of concepts become visible

through the use of different semiotic resources; for example, through talk, gestures, or the use of materials (Jewitt, 2011; Siry et al., 2012).

To capture the meanings made about evolution, two aspects are of great importance. Firstly, meanings can be expressed via spoken language and/or other modalities (Jewitt, 2011). Secondly, capturing children's meaning making requires me to interpret what they express. In this regard, what Lemke (1998) describes as the *presentational aspect of meaning* provides a helpful theoretical frame. The presentational aspect of meaning reflects how language is used to construct a theme or topic. Thus, it functions to discern how something is talked about and how themes or topics emerge in interaction with others.

Another relevant term in relation to how children's meaning making can be captured is *thematic patterns* (Lemke, 1990). A thematic pattern shows "what many different ways of saying 'the same thing' have in common" (p. 87). This means that the same meaning pattern might be expressed in different ways, with different words and through different modalities. In other words, the thematic pattern reveals the common denominator. In this thesis, the common denominator is seen as the meanings made when children engage in activities designed to stimulate meaning making about evolution.

Meaning Making Involves Semiotic Resources

A sociocultural perspective on meaning making acknowledges that people use social and cultural tools in communication. These tools are described as both intellectual, such as symbols (e.g. the alphabet or emojis), and also as physical artefacts, such as pens, paper, pictures and so on (Ivarsson et al., 2011). Using the terminology from social semiotics, such social and cultural tools are called *semiotic resources* in this thesis.

Semiotic resources are crucial in meaning-making processes (Jewitt, 2011; Selander & Kress, 2010; Van Leeuwen, 2005). Semiotic resources are defined as "actions and artefacts we use to communicate" (Van Leeuwen, 2005, p. 3). This means that embodied communicative actions, such as verbal speech, gestures, gaze, and body position, as well as materials such as maps, PowerPoint presentations, books, or this text, are semiotic resources.

In relation to science education, previous studies have shown that, when there is no shared scientific language, semiotic resources such as

gestures and materials support students as their scientific language gradually develops (Roth & Lawless, 2002). However, people use multiple semiotic resources to communicate even when they do have a "shared scientific language". Therefore, semiotic resources are not to be considered temporary props waiting to be removed once the scientific language is sufficient.

Van Leeuwen (2005) states that a semiotic resource is always simultaneously both a material and a social and cultural resource. This entails that all semiotic resources have a *meaning potential* based on past use that is actualised in concrete social contexts. Drawing on Gibson's[11] work (Gibson, 1979), Van Leeuwen (2005) claims that, in contact with a semiotic resource, people might observe different aspects, depending on both the context and the person's needs, interests, and previous experiences. For example, sticking out your tongue means that you are using your tongue as a semiotic resource. When you stick out your tongue, the context will determine how this will be perceived. If you are seeing a doctor for your sore throat, it will be regarded as appropriate patient behaviour. If you are in Tibet, you are showing respect by greeting the other person. If you are in a meeting at a Swedish university and stick out your tongue as a negative response to a proposed idea, you would probably be viewed as unprofessional. The notion of contextualised meaning potential is similar to the view of gestures as coupled with the environment (Goodwin, 2007), described earlier.

Semiotic Resources in Science Education
The science classroom is packed with materials that can be used as semiotic resources. For example, there are images, teacher-produced materials, photographs, books etc.[12] This section outlines some of the findings

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[11] Gibson coined the term *affordance* to describe how the use of materials extends beyond the intended (i.e. designed) purpose. However, the term affordance is not used in this thesis.

[12] In some literature, the terms model (e.g. Justi & Gilbert, 2000) or representation (e.g. Prain & Tytler, 2012; Stenlund, 2019) are used to describe materials that are designed with the intention of illustrating science concepts (e.g. the atom model and the evolutionary tree). In this thesis, I make no distinction between different types of materials and their intentions. That is, I only study the use of materials as semiotic resources.

on how children in early childhood education make use of different materials as semiotic resources in their meaning making.

The power of having access to materials in meaning making is shown in a study by Schoultz, Säljö, and Wyndhamn (2001). In their article *Heavenly talk: Discourse, artifacts, and children's understanding of elementary astronomy,* the authors critically analyse previous studies on children's understanding of astronomical concepts (e.g. gravitation). In their study, the authors provided children with a globe as a "tool for thinking" during interviews about gravity. Earlier on, studies by Vosniadou and Brewer (1992) had shown that children often express so-called misconceptions in response to questions such as "Is there an end or an edge to the earth? If there is, could you fall off this edge?" When the children in Schoultz et al.'s study consulted the globe in front of them while answering similar questions, none of the previously reported misconceptions were expressed. Instead, most children said that gravity caused people to stay on the earth – a scientifically correct explanation. Having access to a physical material thus seemed to enable the children to talk about an abstract science phenomenon.

Oliveira et al. (2014) have studied meaning making about science during read alouds. They suggest that, in a read aloud, meaning making "extends beyond text delivery" (Oliveira et al., 2014, p. 665). When the teachers in their study read science texts aloud to their students (4th grade), the teachers made different types of gestures and engaged pictures in the read aloud. Oliviera et al. highlight the importance of pictures as resources for meaning making. They argue that pictures in books do more than simply engage children during read aloud. Rather, the children draw upon these pictures in their meaning-making processes; therefore, teachers should choose materials, for example books, with engaging and informative illustrations.

Wilson and Bradbury (2016) engaged 6–7-year-old children in learning activities about Venus flytraps through multiple materials, such as physical specimens, photographs, and videos. They evaluated the children's learning gains through both drawings and writings. Their findings indicate that the children's understanding of the structure and function of the Venus flytrap increased and that the children synthesised information from the different learning materials. Therefore, Wilson and Bradbury suggest that children should be provided with opportunities to

both learn and be assessed through different modes. This is in line with Bronner's (2014) assumption that meaning is not made within different, isolated modes. Instead, modes are intertwined and hybridised. Therefore, it is crucial to provide children with different kinds of relevant materials to use as semiotic resources in their meaning making. Similarly, Britsch (2019) argues that children's own photographs of science investigations provide insight into the child's relationship to science inquiry in a way that verbal talk might not do. That is, what is communicated in, for example, a photograph or a drawing, extends and sometimes also opposes what children express verbally.

As suggested in the previous section, people might observe different things in a piece of material, depending on their interests and previous experiences (Van Leeuwen, 2005). Along the same lines, Säljö and Bergqvist (1997) suggest that sociocultural experiences are critical in regard to what people are able to see. They exemplify this by painting a scene in which two people, an expert and a novice, are sitting next to each other at a soccer game. The two are exposed to the same event, but they see and interpret the game differently. The one with great expertise sees tactics, while the novice sees people running around. In the science classroom, teachers have greater expertise than children. The teacher's and the children's perceptions and use of a material might therefore differ. In a recently published Swedish thesis, Bergnell (2019) sheds light on critical aspects of supplying children with materials. Bergnell studied how children (4–6 years old) make use of materials in meaning making about science in preschool. For example, she studied children playing a board game about the water cycle. Bergnell found that the children tended to focus on other aspects, such as winning the game, not on the scientific content of the game. Bergnell problematised the use of materials in preschool science and argued that teachers need to carefully guide children to interpret materials.

In summary, it is evident that children make meaning through many different modes and use materials as semiotic resources when they engage in activities with a science focus. However, providing materials to children does not automatically mean that they will use them in the way the teacher intended.

Meaning Making in Interaction

This thesis explores children's meaning making as they engage in group-based activities. Therefore, interaction is an important aspect of the meaning-making processes studied in this thesis. However, interaction is a versatile term[13]. In this thesis, interaction is defined as a multimodal communicative exchange between at least two people. The word *exchange* is crucial. In contrast to the term *communication,* interaction includes an exchange between at least two actors, where meanings are both distributed and interpreted. I study children's meaning making as they engage in group-based activities where I am also present. The interaction in the group activities can be described as both child–child and child–adult interaction.

The role of interaction between children engaging in meaning making about science has been studied by several researchers. For example, Siry (2013) suggests that "when children are engaged in collaborative open-ended activities, science emerges from their interactions" (p. 2410). Moreover, Murphy, Murphy, and Kilfeather (2011) have shown that, when children work in small groups, they are enabled to share ideas, build upon a presented idea and help scaffold one another's ideas. When interacting in groups, previous actions, both verbal and gestural, can be used as "building blocks" to further their common meaning making (Granott, 1998).

In group-based activities, meanings can be co-constructed. However, this co-construction of meaning can be carried out in several ways. Meanings can be co-constructed through confrontation (Jiménez-Aleixandre et al., 2000), through the integration of ideas (Mueller, 2009), or as a result of trying to reach consensus (Naylor, Keogh, &

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[13] Interaction has been defined as "reciprocal face-to-face action" (Robinson, 2005, p. 7). Some researchers argue that humans can interact with themselves through thinking, or interact with a learning content through reading (cf. "Learner-Content Interaction", Moore, 1989). Other theories, such as Actor-Network Theory, acknowledge materials as actors in interaction (Fenwick & Edwards, 2010). This means that, from an Actor-Network Theory perspective, interaction is not restricted to human–human interaction, but also include human–non-human interaction.

Downing, 2007). Thus, interactions among children can have various characteristics.

In this thesis, I use Granott's (1993) interaction model as an analytical lens to characterise interactions when children engage in tasks with a science focus. Granott's interaction model is further described in Chapter 4.

As part of this thesis, I study meaning making in interactions occurring during read aloud. As an interaction, *read aloud* is a versatile term. It is not a one-way-practice. Conclusively, interaction within read aloud can have different characteristics. The following section provides a theoretical foundation for interaction in read aloud.

Interaction in Read Aloud

Teale (2003) states that reading is not just reading. Instead, read aloud can be carried out in several ways. One approach in read aloud that varies is the extent to which listeners participate in the reading, or how "scripted" the read aloud is. An extremely scripted version of read aloud is when a priest reads a passage from the Bible at church. No one in the community speaks and the priest does not deviate from the text. In Swedish preschool practices, reading and listening to stories in preschool is far from one-way communication (Cekaite & Björk-Willén, 2018). Instead, read aloud is co-operatively accomplished and both listeners and reader deviate from the text (Cochran-Smith, 1984). Read aloud in preschool can be described as *dialogic* (Zevenbergen & Whitehurst, 2003).

Dialogic reading is a strategy whereby the reader engages listeners in communication by continually asking questions, providing prompts and discussing the story. Thus, in comparison to the more monologic approach carried out by priests, the listener participates actively in the reading. Through dialogic strategies, teachers can actively engage children in sharing ideas with each other (Lennox, 2013). Moreover, in relation to science education, dialogic reading has been shown to enhance children's language development and word comprehension (e.g. Pappas, Varelas, Patton, Ye, & Ortiz, 2012; Ping, 2014).

From a social-semiotic perspective, the read aloud of science texts is seen as a multimodal communicative event (Oliveira et al., 2014). A sociocultural view of read aloud entails that the understanding of a story occurs within social interaction. In this regard, the reader and listeners cooperatively and interactively participate in negotiating the meaning of

the story, a process referred to as *interactive negotiation* (Cochran-Smith, 1984). In contrast to the perspective from which books are seen as media that passively transfer knowledge to the reader and listener, interactive negotiation requires the meaning of the text to be "jointly worked out" (p. 260) through interactions between the reader and listeners. This means that, even if several groups of people read the same book, different stories and meanings are made depending on the interactive negotiation. One way of negotiating the meaning of a story is to relate "life to text" (Cochran-Smith, 1984) by evoking personal experiences in relation to the story. Similarly, Varelas et al. (2014) have revealed that children expand upon written texts through reasoning, while connections can be made between the scientific explanations in the text and their own everyday experiences. Varelas et al. describe the child's experiences and way of being as "the first space". The science text, with its scientific explanations, is called "the second space". The intersections between text and everyday experiences are referred to as "third spaces". Third spaces support children's meaning-making processes.

In this thesis, the process of interactive negotiation is seen as occurring within the context of *interactive reading* (Oyler, 1996) which, as dialogic reading, includes interaction. One thing that distinguishes interactive reading from dialogic reading is the level of participation. More specifically, the view of the child as co-constructer in the read-aloud context stands out in comparison to dialogic reading. In interactive reading, the listener is not merely "allowed" to answer questions or engage in discussions initiated by the reader. Instead, the reader "genuinely shares, not abandons, authority with the children" (Smolkin & Donovan, 2003, p. 28). However, even if teachers want to hand over power to children during interactive reading, they are still the authorities in school. What is important in relation to interactive reading is that children's spontaneous questions or queries are embraced during the reading activity (Oyler, 1996).

In summary, in this thesis, interaction between children during read aloud is seen as a way to create a context in which children can make meaning together. That is, in interactive read aloud, children are provided with the opportunity to draw from ideas informed by their own lives and understandings, and through this process, meanings are made (Wiseman, 2011).

Methods

This chapter outlines the data collection and analytical methods used in this thesis. The thesis builds from video data collected on two occasions, which have been analysed using several analytical tools. The chapter begins with a description of how to find a method and a setting for studying meaning making.

Finding a Way to Study Meaning Making

When planning a study, there are many choices that need to be made. As already described, this thesis aims to explore how different resources – material resources such as teaching materials, task contexts, and interaction – influence meaning making about evolution. I have had some ideas about aspects that might affect the meaning-making processes, such as the kind of materials that are provided and how tasks are framed; that is, whether they are scripted or more exploratory. Therefore, three different "tasks" were designed: A group discussion about reasons for animal diversity, an interactive read aloud and a modelling activity, all of which relate to natural selection. Even though I want to explore new ways of letting children encounter evolution, the tasks recognise the "in-between" (Lago, 2014) character of preschool class practice as a play-based practice with play-based schooling materials. Discussions, read aloud, and modelling are all common activities in preschool class practice.

Finding Contexts to Study Meaning Making

The first data collection was performed during the spring of 2015 and comprised a group discussion task. While planning the first data collection, I contacted the principals at two schools. One of them, the principal at a school where I had previously worked (School 1)[14], was positive about the study. The other principal said that the school did not have time to

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[14] The principal did not work there during my time as a teacher at the school. Furthermore, when planning the study, I had not met the preschool class children in School 1, even though two of them were younger siblings of two of my former pupils.

allow me to perform the study. School 1 was chosen to be the only school included in the group discussion task. This choice was based on the fact that School 1 is a typical municipal school in Sweden.

The second data collection took place during the late autumn of 2017 and comprised the read-aloud task and the modelling task. While planning this part of the study, I contacted two municipal schools with different socioeconomic characteristics (School 2 and School 3). Both have two preschool classes. However, the teachers in one of the classes at School 2 declined to participate in the study. Consequently, the second round of data collection includes children from three classes at two schools.

Links between the Theoretical Framework and Research Design

The group discussion, the read aloud, and the modelling activity were designed in alignment with the theoretical perspective outlined in Chapter 3. In a further description of this relationship, this section describes the links between the theoretical framework and the research design (Figure 1).

The theoretical framework outlines three lenses through which to study meaning making about science: a science focus, semiotic resources, and interaction. These three aspects can be seen in each of the three tasks to varying extents.

The science focus of meaning making is explored through probing either the children's previous experiences or their science meanings. In the first task, the group discussion, the children were asked to ponder reasons for animal diversity before discussing this in groups. However, the children in the group discussion task received no communicated science content in terms of instruction. The read aloud task and the modelling task provided conceptual input on natural selection through the storybook *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017).

Materials that had the potential to be used as semiotic resources were provided in all tasks. During the discussion task, the children had access to figurines, a world map, and photographs. These materials can be described as concrete, but movable. In the interactive read aloud, the chil-

dren were positioned in a way that enabled them to have access to a storybook with coloured pictures. During the modelling activity, the children modelled a fictitious animal living in a future changed environment. The children had access to concrete materials, namely already-made figurines and photographs displaying a changed environment. The clay which the children used can be described as a manipulable material. By altering the materials in the three tasks, I was able to explore how different materials are used in the children's meaning-making processes.

All tasks were carried out in groups (3–4 children). However, the character of interaction differed between the tasks. When analysing the group discussions, the focus of Paper I is solely on child–child interaction, while Paper II also includes child–adult interaction. The read aloud was studied as an example of interactive reading and the modelling task focuses on both child–adult interaction and child–child interaction. By studying the character of the interactions during these tasks, the thesis can provide insight into how interaction influences the meaning-making process.

The tasks are framed in different ways and have different characteristics. The research design of each task is described in more detail below.
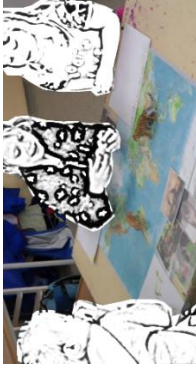
	Group discussion	Read aloud	Modelling
Science focus	Reasons for animal diversity. No communicated conceptual input	Natural selection. Communicated conceptual input (storybook)	Natural selection. Communicated conceptual input (storybook)
Interaction	Child–child (Paper I and II), Child–adult (Paper II)	Child–child–adult	Child–child–adult
Materials used as semiotic resources	Figurines, photographs, world map	Storybook	Storybook, premade models, photographs, and clay

Figure 1. Schematic illustration of how the theoretical lenses are reflected in each respective task. The first row, science focus, provides information about conceptual input. The second row, interaction, describes the nature of the interaction. The third row, Materials used as semiotic resources, presents the materials provided. (Image from the storybook is reproduced with permission from Tumblehome Learning, Inc.)

Research Design – Group Discussion

Twenty-seven children from two preschool classes at School 1 partici-pated in the group discussion task. Before the group discussion com-menced, all the children participated in two preparatory tasks: a drawing session and an individual interview. The preparatory tasks are not used as data in this study. Instead, they served as a way to probe the children's previous experiences about animal diversity. In both preparatory tasks and the group discussion, the children were asked to talk about the fol-lowing question: "Lions, tigers, snow leopards, and jaguars are all big cats. Several million years ago, all big cats looked alike. Why do they look so different from each other today?" The children were provided with photographs of a tiger, a lion, a snow leopard, and a jaguar in their nat-ural habitats and toy figurines of the cats placed at their natural geo-graphical location on a topographical world map (Figure 2). The same materials were provided in both preparatory tasks and in the group dis-cussion.

Figure 2. Materials provided in the group discussion task and accompanying preparatory tasks

Preparation Activities

Initially, groups of five children each drew individual pictures represent-ing their ideas about why animals are different. The materials (Figure 2) were placed on a table in the centre of the room, and were available to all

the children. The children were told that they did not have to produce a "pretty picture". Instead, they were encouraged to make a drawing that could help them remember their idea, so that it could be discussed later.

The choice of allowing the children to draw was not based on the idea that I would analyse their drawings as a product or representation of their understanding (cf. Andersson, Löfgren, & Tibell, 2019). Instead, in line with Robbins (2005), I viewed the process of drawing as way to support the children's meaning making.

In the individual interviews and group discussions that followed, the drawings served as a shared reference point (Tytler, Prain, & Peterson, 2007). Thus, they could be compared to artefacts, enabling more capable reasoning (Schoultz et al., 2001) and as semiotic resources (Van Leeuwen, 2005) in the meaning-making process.

The preparatory individual interviews were designed to allow the children to elaborate upon their ideas about why animals are different from each other today, when they looked alike several million years ago. The children's drawings were used as a starting point in the interviews.

Group Discussion about Animal Diversity

Eight groups of three to four children were formed based on the individual interviews, aiming to create groups with a potentially wide range of meanings.

The group discussions took place in a room where the children engaged in regular activities during the school day. Thus, it was a familiar environment for them (cf. Parkinson, 2001). The children sat at a table, two on each side, and I sat on the short side of the table. The map with the figurines was placed in the middle, and photographs of the animals were positioned on each side of the table. The children also had their drawings near to themselves (Figure 3).

Figure 3. Placement during the group discussion about animal diversity

At the beginning of the discussion, the question of why animals are different today was repeated. The children were then asked to tell each other about their ideas. They were also encouraged to discuss, ask questions of each other and to speak their own minds.

During the discussions, I asked the children to elaborate upon their answers. If the discussion started to flag, I directed their attention to the materials. If a child was passive in the discussion, I reminded them of what they had talked about in the individual interview in order to include them in the discussion. Thus, my approach during the discussion was similar to approaches used in focus groups, in that I aimed to maintain the focus on the interactions between the children, not an alternation between myself and the children (Morgan, 1997).

In some discussions, the children strayed away from the task more than in others. If the situation appeared to be getting out of hand (e.g., if they started to talk about what they would do at the weekend), I picked up something one of them had said earlier to stimulate the discussion. However, I rarely did this, since I wanted to interfere as little as possible in the discussions.

Research Design – Read Aloud

Forty children from three preschool classes, 13 from School 2 and 27 from School 3, participated in a read aloud of the storybook *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017). The children were read to in groups of 3–4 (N=13). The content of the storybook is described briefly below.

The Storybook *How the Piloses Evolved Skinny Noses*

How the piloses evolved skinny noses[15] (Kelemen & The Child Cognition Lab, 2017) is a picture book (Giorgis, 1999) that communicates seven biological concepts related to natural selection. Large images occupy approximately 70% of each page spread (Figure 4). The text and pictures communicate the story in combination.
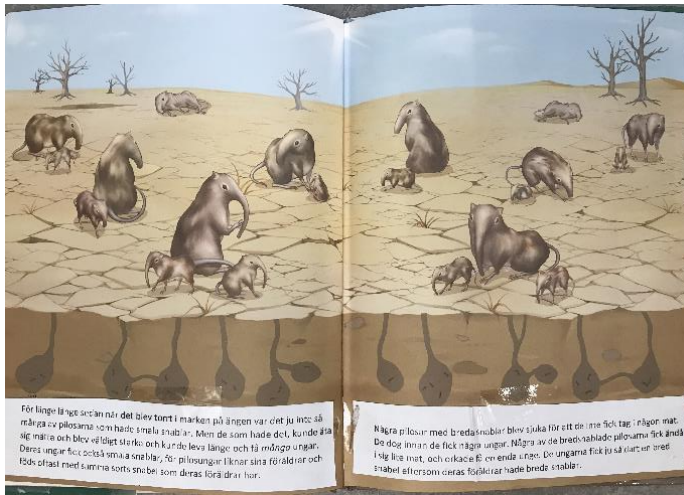
Figure 4. Pages 12–13 of the storybook (Kelemen & The Child Cognition Lab, 2017) showing an image of the fictional pilose mammal species in their environment. A translated Swedish text is taped over the original text. (Image of the storybook is reproduced with permission from Tumblehome Learning, Inc.)

Table 1 presents the seven biological concepts and how these are described in the book.

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[15] The following link provides a YouTube video in which the storybook is read aloud by a person at the Child Cognition Lab
https://www.youtube.com/watch?v=nUyVd1pO3nI

Table 1. Biological concepts described in the storybook (Kelemen & The Child Cognition Lab, 2017) based on Emmons et al. (2017, p. 7)

Biological concepts	**Description in the storybook**
Trait variation inherent to a biological population	Piloses have either wide or skinny trunks.
Ecological habitat and food-source change due to climate change	At the beginning of the book, the piloses live in grass-covered fields. Then, the weather changes and becomes very hot. Concurrently, the pilose food source (milli bugs) retreats down narrow tunnels.
Differential health and survival due to differential access to food	Piloses with skinny trunks can reach down the narrow tunnels. However, piloses with wider trunks cannot. Consequently, piloses with wider trunks become weak and often perish.
Differential reproduction due to differential health	Piloses with skinny trunks have two or more children while piloses with wider trunks have one child or none.
The reliable transmission of heritable physical traits across generations	Pilose children resemble their parents. Adults with skinny trunks have children with skinny trunks and adults with wide trunks have children with wide trunks.
The stability and constancy of inherited traits over the lifespan	Piloses that are born with wide or skinny trunks maintain this feature throughout life.
Trait-frequency changes (i.e., adaptation) over multiple generations	Trait frequency gradually changes across generations. At the end of the book, a majority of piloses have skinny trunks.

Translation of the Storybook

In preparation for the data collection, the storybook *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017) was translated into Swedish, retaining the original scientific meaning of the book.

During the translation process, I collaborated with three experts. Professor Bengt-Harald (Nalle) Jonsson focused on the biological concepts, making the translation scientifically correct, in line with the original version. Dr. Bodil Sundberg provided input from a pedagogical point of view. Associate professor Polly Björk-Willén, helped to adjust the translation of the text to align with the vocabulary of a typical Swedish six-year-old.

A final sentence was added to the book, which presented the idea that the evolution of piloses had not come to an end only because the story had ended. This sentence was phrased as: "What would happen if the weather changed again? We will have to wait and see what the future holds" (Sv: "Men vad skulle hända om vädret ändrade sig igen? Det får vi se i framtiden").

Different Readers Reading the Storybook

In School 2, the children's ordinary teachers read the book to the children. In School 3, all but one of the groups were read to by me. There were two reasons for the reader switching between the schools. Firstly, it was a pragmatic solution since the teachers in School 3 had trouble finding both the time to read and a calm place to conduct the read aloud. The place that they normally used for small-group work was being used for the modelling activity (described later in this chapter). Secondly, reading the book myself made it possible to reconnect to what the children had said during the read aloud later on during the modelling activity.

As shown in Table 2 (data corpus table, p. 74), eight read-aloud sessions are analysed in this thesis. These eight groups were all read to by me. The choice of only analysing these eight read-aloud sessions was based on three reasons. Firstly, I wanted the reading to be interactive. This approach was more likely to be achieved when I was the reader, since I did not coach or control the other readers' reading approaches. Secondly, having the same reader is more likely to produce comparable data. Different readers have different approaches to reading aloud. For

example, readers vary in their degree of interaction and the character of prompts, while individual readers are often quite consistent in their read-aloud strategies (Martinez & Teale, 1993). Thirdly, the analytical focus of Paper III is on child-initiated turns (Oyler, 1996). In viewing the video data from the read-aloud sessions, more child-initiated turns were present in the sessions where I was the reader compared to the sessions with other readers.

Among the groups that had a reader other than myself, the read aloud is seen as a preparation task for the modelling activity. The following section describes how the interactive read-aloud sessions were carried out.

Reading the Storybook in an Interactive Manner

During the read aloud, the children were seated on the floor beside me. The storybook was held downwards, ensuring that all the children could easily see the pictures in the book (Figure 5).

Figure 5. Placement of the book relative to the children during the read aloud

During the read aloud, dialogic strategies (Lennox, 2013; Zevenbergen & Whitehurst, 2003) were applied. In addition, the children's questions and comments were embraced (cf. Oyler, 1996). Sometimes, I paused and rephrased the text to make sure that the children were following. For example, I stopped at the first spread, which showed the variation in the population, and asked "Do you see that they look different?" Another question was "Why did some of the piloses not get any food at all?" Furthermore, I engaged with the book's pictures by pointing during the reading.

Research Design – Modelling Activity

The same cohort of children as those in the read aloud participated in the modelling task (40 children, 13 groups), which commenced directly after the read aloud. The modelling activity was designed to explore how the children transferred meanings made about natural selection from the interactive read aloud to another context.

Introducing the Modelling Task

The children performed the modelling task seated at a table. Four already-made clay piloses, resembling the piloses depicted in the book, were placed in the centre of the table (Figure 6). Three of the clay piloses had skinny noses and one had a wide trunk. Their bodies differed slightly in colour and size (Figure 7). These clay piloses are referred to as the now-piloses (NPs). The NPs were placed on two identical photographs resembling the environment in which the NPs lived after the weather change (Figure 7). This environment is referred to as the now-environment (NE).

Figure 6. Placement of the children and myself (in the middle) during the modelling task
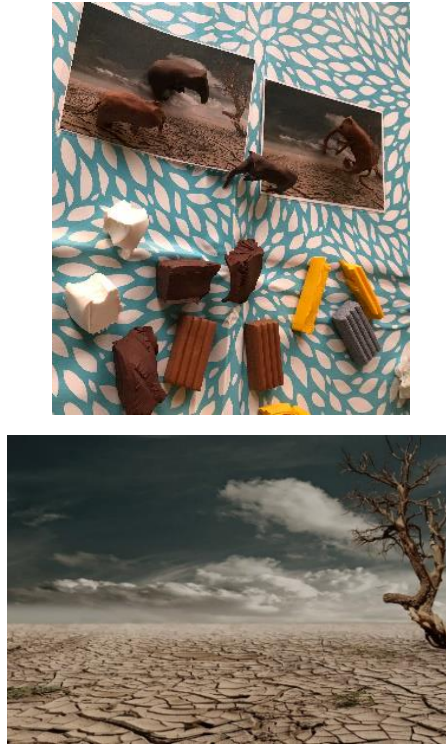
Figure 7. Materials used during the modelling task, comprising the NPs, the NE and clay of different colours (top) and a visual image of the NE. (The image of the NE is in the public domain and was obtained from pxhere.com, which is an open-access database.)

Often, the children started to touch the NPs and name them as "pi-loses" upon approaching the table. If they did not, I pointed to the NPs and asked the children if they recognised the figurines.

The modelling task started with me reminding the children about the ending of the storybook. That is, that we would have to wait and see what the future holds for the pilose population. Then, each child was handed a photograph. The photographs showed environments differing from the NE, either a snow-covered field with a treeline at the horizon, mountains with very little vegetation and a small stream at the bottom of a valley, or a forest with tall coniferous trees and moss on the ground. Children within the same group were provided with the same photograph. This means that all the children in, for example, the first group were provided with a photo of the snow environment. The photographs were introduced

as portraying the piloses' habitat in "the future". From now on, these photographs are called future-environments (FEs). Figure 8 depicts the photographs of the FEs.
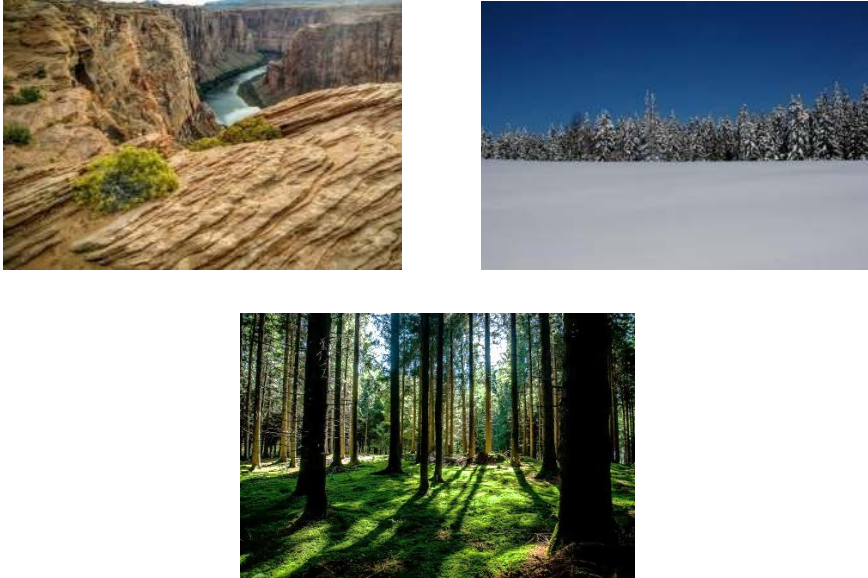
Figure 8. Photographs showing the three FEs. In communicating with the children during the task, the photographs were referred to as "mountains" (top left), "snow" (top right), and "forest". (All images are in the public domain and were obtained from pxhere.com.)

Together, the children and I talked about the FE. For example, we discussed temperature (warm or cold) and where the milli bugs might live. This discussion provided input regarding how the children perceived the FE. The children were told that they were going to model a pilose that lived in that specific environment. They were also told that they should describe how their pilose had ended up looking like it did.

The children had access to white, black, light brown, dark brown and yellow clay. These colours were chosen purposefully since they are common colours for animals that have fur, which piloses, according to the images in the book, do.

Probing for Meanings during the Modelling

As the children engaged in the modelling, I probed them about their ideas on how they thought a pilose would look in the FE and why it would look like that. This type of interaction often began with me paying attention to the children's models. For example, I might ask "I see that you're making legs/a trunk/a pattern on the back of your pilose. How would you describe the legs/the trunk/the pattern on the back of your pilose?" Next, I asked questions about the origin and functions of this bodily feature. This approach was designed to get the children to describe their meanings while they were actively doing something (cf. Parkinson, 2001). At the end of the modelling activity, the question about why the children's piloses looked the way they did was repeated.

Collecting Data that Captures Children's Meaning-Making Processes

Data was collected using video and still photographs. All tasks were video recorded. Goodwin (1994) suggests several benefits of using video when studying interactions and the situated use of materials. Firstly, a video camera captures body movements in a way that audio alone cannot. Secondly, video data allows the repeated and detailed examination of particular sequences. Thirdly, when they have access to video, other researchers can watch the material and confirm or challenge the analysis. Therefore, video recording provided a fruitful way to capture the children's meanings and how materials were used as semiotic resources during interactions.

In order to capture the handling of materials during the tasks, I had to carefully consider the placement of the video cameras. I chose to use a static view, using tripods. This is what Luff and Heath (2012) call a "mid-shot". A mid-shot typically focuses on two or three people. The camera is set up slightly above the participants and angled downward.

When video filming the group discussions, two cameras were placed at opposite sides of the table where the children were seated, angled to capture both the children and the materials on the table. The read aloud was video recorded using one camera. This camera was placed in front of the group and myself and aimed to capture both the children's and my gestures towards the book. During the modelling task, the placement of

the cameras was similar to during the group discussion task. That is, two cameras were used and placed to capture both the children and the materials on the table. However, at School 2, the cameras were placed at a more diagonal angle in relation to the table, due to lack of space behind the children's chairs.

Throughout all the tasks, I handled the operation of the cameras on my own. In addition, I photographed the children's completed models after the modelling task was complete.

Data Corpus Constituting the Thesis

Table 2 presents an overview of the data corpus. As described above, the video data was recorded using one or two cameras to capture different angles. However, the total time presented in Table 2 refers to time captured with one camera.

Table 2. Data corpus showing the data upon which the thesis is built.

Task	Number of groups	Partici-pating children	Range of video time	Total video time	Photo-graphs (number)
Group discus-sions	8	27	11–27 min	181 min	-
Read aloud	8	24	9–10 min	80 min	-
Model-ling	13	40	20–37 min	390 min	40

Handling and Analysing Data

This section outlines the analytical processes in this thesis. The thesis builds upon the video data. I begin by describing how the video recordings were transcribed.

Transcription of Video Recordings

As mentioned, communication is multimodal (see Chapter 3). This entails that, in addition to verbal language, actions during which material

is being used (group discussion and modelling activity), gestures towards the book (read aloud), and handling of clay (modelling activity) were transcribed.

West (2007) highlights the risk of drowning in your own data if you try to transcribe every single mode separately. By constantly keeping the research aim in mind, it is possible to focus and limit what is transcribed. Hence, I have not transcribed gestures, proxemics, or posture if they do not seem essential to the meaning-making process. For example, I have not transcribed actions not immediately relevant to the task at hand.

In transcribing and analysing the data, I acknowledge meaning as made through several modalities (Jewitt, 2011). Modalities sometimes communicate different meanings, and the context needs to be taken into account to achieve a valid interpretation of the meaning making (Goodwin, 2000; Jewitt, 2011). If the meanings expressed in one mode differed from meanings expressed in another mode – for example, if a child in the group discussion pointed at a tiger while talking about "the lion" – this was transcribed. In this specific case, the context of the utterance suggests that the gesture is the priority mode.

By considering communication as multimodal, I can hopefully do the children justice in my interpretations of their meaning making. However, the relationship between transcripts and original video data needs to be recognised (Lemke, 2012). Video and written texts are two separate media. A transcript, no matter how detailed, can never fully capture everything that occurs during an interaction. Therefore, the transcripts have never been the main data in the analysis – the videos are. That is, the videos have the "final say" in how to interpret the children's meaning-making processes.

In transcripts of video data, bodily actions, such as gestures, gaze, or the handling of materials, are described within parentheses. Clarifications are made within square brackets. Overlapping actions are shown by using a handle ([ ) in the margin. Furthermore, in transcripts from the read-aloud sessions, text printed in the book (and read aloud in Swedish) is provided in italics, while interactions taking place outside the text are written in normal font.

Data Analysis

As stated previously, this thesis aims to explore how different resources, such as teaching materials, task contexts, and interactions influence children's meaning making about evolution in group-based tasks. Each paper included in this thesis contributes individually to achieving this aim. As described in Chapter 1, for the purpose of this comprehensive summary, I have chosen to re-analyse some data examples from each task, the group discussion, the read aloud, and the modelling activity, in order to meet the overarching aim of the thesis. By re-analysing examples from each task, there is an opportunity to investigate how the tasks' contexts and interactions affect meaning-making processes. The re-analysed data examples were chosen because they demonstrate a wide spectrum of meanings and use of materials in the tasks.

The current section describes the analytical procedures of re-analysing examples. The analytical framework is summarised in Table 3. For details on the analytical procedures in Papers I–IV, see each paper respectively.

Table 3. Analytical framework used for re-analysing data examples in the thesis. The analytical framework highlights the links between the theoretical lenses and the analytical tools.

Theoretical lenses	Analytical tools

Science focus	*Group discussion* (reasons for animal diversity)
	• Conceptual themes (finding in Paper I)
	    o Kinship and heredity,
	    o Environmental effects,
	    o Need for adaptation,
	    o Need for geographic separation
	
	Read aloud and *modelling activity* (natural selection)
	• Conceptual themes (see above)
	• Biological concepts described in the storybook (Emmons et al., 2017)
	    o Trait variation inherent to a biological population,
	    o Ecological habitat and food-source change due to climate change,

	o Differential health and survival due to differential access to food, o Differential reproduction due to differential health, o The reliable transmission of heritable physical traits across generations, o The stability and constancy of inherited traits over a lifespan, o Trait-frequency changes (i.e., adaptation) over multiple generations.

Interaction	Character of collaborative interactions (Granott, 1993)
	   • Mutual collaboration,
	   • Scaffolding,
	   • Symmetric counterpoint.
	Acts of doing science (Lemke, 1990)
	   • Observe,
	   • Describe,
	   • Compare,
	   • Question,
	   • Challenge,
	   • Evaluate

Materials as semiotic resources	Functions of materials (finding in Paper I)
	   • Communicative tools,
	   • Resources providing meaning,
	   • Argumentative tools

The following sections will further describe how the theoretical lenses are related to the analytical framework. However, in order to understand the analytical procedures, this is preceded by a definition of the units of analysis.

Units of Analysis in the Thesis

The analysis of the group discussions and the modelling task was performed at two levels: the interactional sequence level and the turn level (Hogan, Nastasi, & Pressley, 1999). Coding at the turn level was conducted in relation to the analysis of the science focus in the meaning-

making process, acts of doing science, and how materials are used as semiotic resources (see below). A turn is defined as beginning when a child starts to talk, or performs some other communicative action, and ends when another person starts to perform some communicative action (Hogan et al., 1999).

Interactional sequences consist of a series of turns with the same science focus. Interactional sequences begin and end as the science focus changes (cf. Hogan et al., 1999). Coding at the interactional sequence level was used in relation to the character of interaction in the meaning-making processes (see below).

The unit of analysis in the read-aloud sessions is interactions taking place outside the text. "Outside the text" means all actions and utterances that are not explicitly stated in the text (cf. "extratextual talk" Price, Bradley, & Smith, 2012).

Analysing the Science Focus of Meaning Making
The children's meanings about the reasons for animal diversity (group discussion) and natural selection (read aloud and modelling activity) were analysed through the notion of the presentational aspect of meaning (Lemke, 1998). That is, I analysed how the children used multimodal communication to express meanings.

Firstly, all meanings made in the re-analysed examples have been contrasted regarding their thematic patterns (Lemke, 1990). Secondly, the thematic patterns were compared to the *conceptual themes* Kinship and heredity, Environmental effects, Need for adaptation, and Need for geographic separation. These themes were presented as part of the results of Paper I regarding children's meanings about the reasons for animal diversity. When re-analysing data examples from the modelling task, which were not included as data in Paper I, the themes were still applicable. They are further described in Table 4.

Table 4. Conceptual themes emerging in the children's discussions about animal diversity. The descriptions are adopted from the findings of Paper I. The third and fourth columns provide examples from the discussions concerning underlying reasons for animal diversity among big cats and the children's explanations of pilose development in a changed environment during the modelling activity.

Conceptual theme	Description	Big cats	Piloses
Kinship and heredity	Animals are or become different as the result of breeding.	A snow leopard and a jaguar are closely related because they have a similar fur pattern.	Pilose offspring resemble their parents.
Environmental effects	Animals develop different traits because they live in habitats with different conditions, such as temperature, climate, or food range.	Snow leopards are white because they have rolled in the snow and the snow tainted the fur.	A pilose has a pattern on its back because it was burnt by the sun.
Need for adaptation	Animals that live in different conditions need to adapt to this condition in order to survive. Hence, different characteristics develop.	A snow leopard needs to be white in order to hunt prey without being seen.	A pilose living in the mountain FE has long legs in order to climb the mountains and find food.
Need for geographic separation	Animals live in different environments because of their traits.	A snow leopard has thick fur and "would melt" in a warmer climate. Hence, snow leopards live where it is cool.	*Not applicable in the modelling task where the children were only given one environment.*

Thirdly, meanings made during the read aloud and modelling activities were also analysed in relation to the seven biological concepts (Emmons et al., 2017) described in the book *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017)[16]. A complete list of these concepts is provided in Table 1 in relation to the description of the storybook, and in Table 3. Photographs of the children's crafted models were used as additional data resources in the analysis of children's meanings about the evolution of the piloses.

Analysing the Use of Materials as Semiotic Resources
In Paper I, the analysis explored the function of the provided materials in the group discussion. Here, the analysis was conducted through inductive coding, concentrating on *what* material was used and *how* it was used in the specific situation. The analysis revealed three functions of the materials: *communicative tools, resources providing meaning*, and *argumentative tools*. A communicative tool means that the material serves as a tool for communicating something to another person. For example, the child points at something and says: "that one", which is understood as meaning "the tiger" or "that pilose" or "that environment".

When the material serves as a resource providing meaning, this means that the children observe certain features of a specific material, for example, the bushes in the mountain FE photo (Figure 8), and include these observations in their meaning making to say that piloses might look for milli bugs in the bushes. Materials functioning as argumentative tools means that observed features in the materials are used to argue for an idea or a meaning. For example, in the group discussion, a child observed similar fur patterns in two of the figurines (the snow leopard and the jaguar) and argued that they were related.

In re-analysing examples from the data, I explore the function of the materials provided in each task by performing a deductive analysis of the three material functions: communicative tools, resources providing meaning, and argumentative tools.

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[16] For a more detailed description of the analytical procedure regarding the seven biological concepts, please see Paper III (read aloud) and Paper IV (modelling activity).

Analysing Interactions in the Meaning-Making Processes
Two analytical tools were used to analyse the interactive aspects of meaning-making processes in the re-analysed examples from the tasks. Acts of doing science carried out in interaction were analysed using Lemke's (1990) terminology[17]. The acts coded for were: Observe, Describe, Compare, Question, Challenge, and Evaluate. Moreover, Granott's (1993) interaction model was used to characterise collaborative interactions. This model is described below.

Granott's Interaction Model
Granott (1993) proposed a model for studying interaction and its effects on meaning making. In her work, Granott combines theories from Vygoskij and Piaget to both characterise interactions and suggest the "cognitive effects" of different interactions. However, I take on the perspective of meanings as social constructs (see the section *Meaning making with a science focus*, Chapter 3), not as cognitive changes. Therefore, I only use Granott's interaction model to characterise interactions. In addition, I acknowledge interaction as multimodal (see Chapter 3).

Granott's model displays two major dimensions: Degree of interaction (moderate–high) and relative expertise between the participants (symmetric–asymmetric) (Figure 9).

Highly collaborative interactions are characterised by mutual effort and the sharing of observations, materials, and ideas. As shown in Figure 9, both *mutual collaboration* and *scaffolding* interactions are highly collaborative. Mutual collaboration interactions are characterised by intense communication where turns switch often and rapidly. Speech is often abbreviated, simultaneous, and the interacting people follow each other and complete each other's sentences.

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[17] See Paper II for a detailed description of how the analysis of acts of doing science were carried out.
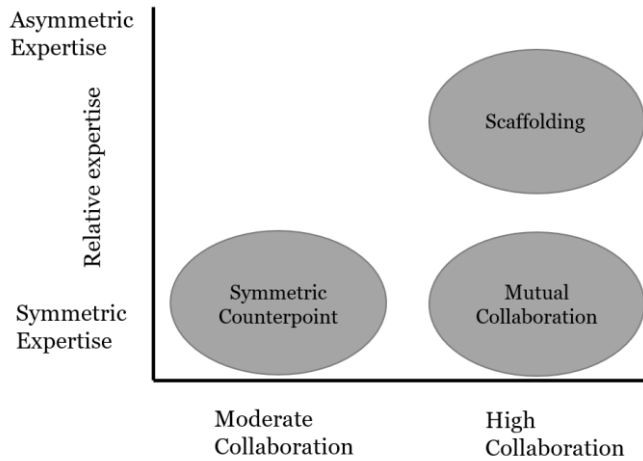
Figure 9. Components of Granott's interaction model (adapted from Granott, 1993, p. 187).

Scaffolding interactions are characterised by the expertise being asymmetric. The person with greater expertise, for example the teacher or an older child, guides or assist the scaffold in a supportive manner. For example, the scaffolder guides the scaffold by directing observations or asking questions, while still acknowledging the scaffold's ability.

In interactions characterised by *symmetric counterpoint,* the participants have the same expertise. However, the level of collaboration is lower. Instead, dominance in the interaction switches between the interacting people; for example, they take turns to talk. As in the highly collaborative interactions, materials are shared. Nevertheless, there might be separate ways of understanding and using the materials (Granott, 1993). This can result in the meanings not being co-constructed.

Mutual collaboration and scaffolding interactions have some shared characteristics. For example, the interacting people share the materials and observations. Granott (1993) states that, within highly collaborative interactions, the context itself is shared and, within this shared context, meanings are co-constructed and inter-subjectivity evolves. However, the asymmetric expertise within scaffolding interactions affects the character of speech between the scaffolder and the scaffold. For example, abbreviated speech is not common, and the focus is on the scaffold's meaning making.

Methods Discussion

This section addresses the methodological strengths and limitations of the thesis. Furthermore, I outline the ethical considerations taken into account and discuss my participation in the tasks.

The analyses described in this thesis are based on both verbal and non-verbal communication. Although it is not possible to make general claims from the results, the analysis and the transcripts presented in each paper enable readers to interpret and evaluate the results.

As described, I monitored the group discussion and the modelling task myself. It is possible that these tasks would have been carried out differently if they had been monitored by the children's ordinary teachers. In addition, the children might have acted in different ways (e.g. more relaxed) with their ordinary teachers. However, as described in relation to the section *Different readers in the read aloud*, teachers vary in the degree of interaction and how they pose questions. Therefore, it is also likely that the children's various teachers would have carried out the tasks in different ways. In turn, having different adults participating in the data collection might impact upon the results (cf. Corbett, 1984; Stewart, Kendrick, & Leighton, 2012).

Moreover, the data collection design contains a few limitations that I shall address in terms of the two data collections.

In the first data collection, the question that the children are encouraged to discuss has one possible limitation. As presented earlier, the question is "Lions, tigers, snow leopards, and jaguars are all 'big cats'. Several million years ago, all big cats looked alike. Why do they look so different from each other today?" It might be problematic for children to understand the phrase "several million years ago". Prior research on people of all ages understanding of geologic time conclude that people in general are able "to place geologic events in correct temporal order on a relative scale, but are unclear about where those same events fit on an absolute scale" (Cheek, 2012, p. 1048). In addition, 10–11-year-olds tend to perceive geological events as falling into two groups: "ancient" and "less ancient" (Trend, 1998). This indicates that long timescales are problematic, and it can be assumed that not all children in the present study would understand the concept of time. However, in their discussions, the children talk about events happening "many millions of years ago", "a

very long time ago" or "before there were humans", which is interpreted as them understanding "several million years ago" to be a distant period.

In the first preparation task, the children were asked to make a drawing as a reminder of their initial thoughts about the posted question. The reason behind this approach is that the process of drawing can support children's meaning making (Robbins, 2005). In addition, other studies (e.g. Brooks, 2009) have shown that children's understanding of scientific phenomena can be developed through the drawing process. However, some children in this study did not want to draw and chose to write instead, and some children seemed to have difficulties representing their meanings in a pictorial mode and simply drew "a cat". In these cases, ideas about the process of evolution or speciation are not visible in the drawings. This might be a result of difficulties with drawing "a process". Maybe six-year-olds are too young to do this? In addition, one of the six-year-old children said that he was not "made to draw", but he was "made to build stuff". This statement might be an expression of preference for the communicative mode. Consequently, it is not certain whether the children were able to use their drawings as a shared reference point (Tytler et al., 2007) in the subsequent group discussion.

In relation to the second data collection, the modelling activity came with some methodological challenges. Firstly, shaping and kneading the clay was difficult for some children. Secondly, some children wanted their pilose to look like the NPs, and were frustrated by the difficulty of handling the clay.

The children were encouraged to make their pilose just as they wanted, and to do so on their own, but many children wanted me to help them. I decided that I would not refuse, since this might end up with them getting frustrated or abandoning the task. Instead, I supported them in their making of the piloses in the following ways. For example, if a child asked for help with forging legs, I first asked how many legs the child envisioned the pilose to have and where they should be positioned on the body. Then, I supported this progression by shaping out short legs before handing the pilose back to the child and telling her/him to continue with their envisioned pilose. I also provided verbal support, guiding the child by suggesting how they could handle the clay (e.g. "Start by making a cylinder/a sausage").

During the modelling, I asked the children about their ideas on how the pilose would look in the FE and why it would look like that (see section *Probing for meanings during the modelling*). The dilemma here is that I did not want to interfere too much in the children's modelling – hence, I refrained from interjecting as much as possible. At the same time, I wanted to understand the children's actions and capture their reasoning. Therefore, I asked them about their expressed meanings at regular intervals during the process.

Ethical Considerations

My research project follows the ethical guidelines stated by the Swedish Research Council (Vetenskapsrådet, 2011). All data, both raw material and edited pictures, have been kept in a locked space to which only I have access.

Informed Consent
To gain access to the children in the current studies, I needed consent from school principals, caregivers, and the participating children. For the second data collection, I also needed permission from the teachers who participated in the read aloud. Before both data collections, I contacted the principals of the schools by telephone. After an initial conversation, an e-mail with further information attached (Appendices 1 and 2) was sent. Caregivers were informed of the aims and methods of the studies by the children's teacher and by a letter (Appendices 3 and 4). Consent was given in writing (Appendices 4, 5, and 6). Children who wanted to take part in the activities, but lacked consent from their caregivers, did not participate in the data collection.

During my first visits to the classes, I talked to all the children and informed them about what I was doing there and that I would like them to take part in activities that included talking to me alone and in groups and that I wanted to video record the activities. Ethical guidelines explicitly state that all participants must have the opportunity to approve or decline to take part in research at any time during any data collection. The children verbally gave their consent to me before all the activities.

One child at School 2 opted out of the data collection during the modelling activity. In addition, one child at School 3 opted out during the read aloud. These children have been excluded from the data corpus.

Moreover, one other child has also been excluded from the data because he was left alone in his group when his peer opted out.

Mutual Trust

To create mutual trust, I met with each class two or three days before each data collection began. I took part in ordinary classroom work, had lunch together with the children and played with them during breaks. This approach is similar to that of other researchers working with children (e.g. Parkinson, 2001; Wiseman, 2011). By the time of the second data collection, I had also followed the classes to Christmas plays and a school play taking place on the days I spent with them. My aim was for the children to accept me as an adult in their classroom. Most children did accept me and wanted me to interact with them. For example, they asked me to come and sit at "their table" in the canteen or asked me for help. This approach towards building trust between me and the children was the same in all schools and during both data collections.

Ensuring Anonymity in Multimodal Analysis

In multimodal studies, visual transcripts are sometimes used to show positioning, handling of material, gestures, and other behaviours. If changes in bodily actions are the focus of the analysis, faces can be blurred, or the picture can be edited to exclude faces. It is more problematic if the researcher is interested in investigating facial expressions and/or gaze (cf. Flewitt, 2006). Much non-verbal communication depends on slight shifts in facial expressions. Hence, if there is a need to show faces, it is more difficult to guarantee confidentiality.

When presenting my results, I have edited photographs of the children in two primary ways. When gaze or facial expressions have been of importance to the results, I have used filters (see, for example, Figures 3, 5, and 6). I have shown some of these pictures to the children's teachers, who have not been able to recognise them. When gaze or facial expressions have not been needed to illustrate the results, I have simply cropped the picture (see, for example, the images in the Appendix to Paper II).

Researcher as Participant

As described, I participated in the data collections. I am the only adult who interacted with the children throughout the analysed tasks. My role

as a teacher or reader is specifically considered in the analysis sections of Papers II, III and IV. This means that my own actions are also part of the data set. In order to analyse myself, I needed to distance myself as a teacher/reader from myself as a researcher. One way of dealing with this challenge has been to watch the videos several times and make detailed transcripts. Another way to handle the fact that I am analysing myself has been to be very systematic and to use transparent analytical tools. Furthermore, I have discussed the analysis on several occasions with my supervisors and in several rounds with other colleagues in research seminars throughout the process.

   One aspect that has facilitated objectivity is that, when the two data collections were planned and implemented, the intention was not to analyse my own actions as part of the children's meaning-making processes. Instead, analysing my actions was a result of research questions that arose during the analytical process – after the data collection. In the first data collection, the intention was to focus on child–child interactions. My role in the discussions was meant to be largely observational. Therefore, I did not act as a teacher. In fact, I carefully avoided "teaching". For example, I did not correct the children when they expressed "misconceptions". Instead, my focus as a researcher was to keep the discussion going by asking clarifying questions ("What do you mean?") or challenging questions ("What would happen if…?"). However, during the analytical process of Paper I, I realised that the discussion between the children depended on how active I was. Consequently, I decided to investigate whether this was the case. The analytical process in Paper II involved the application of several analytical tools in order to make the analysis transparent (see the methods in Paper II). Nevertheless, it is of course possible that I would have analysed other adults more closely, or in another way, due to greater objectivity. In turn, this might have revealed other results (cf. "participant observer" Saracho, 2015).

   In the second data collection, the intention was to have the children's ordinary teachers read the storybook. However, as described, this intended plan was altered due to several circumstances. Consequently, I read the storybook to most groups. In the moment of data collection, I did not intend to analyse the read-aloud sessions. That is, when I was planning and carrying out the second data collection, the read aloud was merely seen as a preparation task. Similar to the drawing sessions and

the individual interviews in the first data collection, in the read-aloud sessions, I simply acted as I would have if the children were my own students to whom I was reading a book. In Swedish preschools and preschool classes, read aloud is far from one-way communication (Cekaite & Björk-Willén, 2018). Therefore, the interactive approach to the read aloud was deliberate since, in comparison with previous studies conducted by the research group at the Child Cognition Lab (see Chapter 2 *Using Storybooks to Introduce Evolution*), I wanted to explore the real-time use of the storybook in more authentic classroom settings.

During the process of analysing the interactive reading, I discovered that my actions during the read aloud were not always optimal in terms of being an attentive listener and grasping every opportunity to build on the children's initiations. This is something that demonstrates the authenticity of the task, because it shows that I was not deliberately making an effort to be the "perfect interactive reader". In addition, the fact that I was able to discover limitations in the approach also reassured me that I had distanced myself as a reader from myself as a researcher.

Furthermore, the analytical process of Paper IV was carried out in collaboration with three other researchers, which further reduces the risk of overlooking my participation in the data from the modelling task. Still, one could argue that including yourself as part of the data is a risky business and jeopardises the validity of the research. However, by providing detailed analyses and providing examples from the data, the validity of the results is strengthened (Brink, 1993).

Chapter 5

Summary of Papers Constituting the Thesis

This chapter presents a summary of Papers I–IV, providing a context and the theoretical and methodological perspectives of the papers. In addition, the summary describes the main findings and possible implications of each paper. The findings are further discussed in Chapter 7.

Paper I: "If It Lived Here, It Would Die." Children's Use of Materials as Semiotic Resources in Group Discussions about Evolution

This study provides insight into how evolution theory can be introduced in preschool class.

The analysis takes a multimodal approach and is based on transcribed video data from eight small-group discussions about the reasons for animal diversity. During the discussions, the children were provided with materials comprising a topographical world map, four big-cat figurines (a jaguar, a snow leopard, a lion, and a tiger), and photographs of the same animals in their natural habitats. The results provide a detailed analysis of how the children (N=27) explain their reasons for animal diversity. In addition, the findings reveal the function of materials in the children's meaning-making process.

The findings of the paper reveal that, by using the provided materials and their previous experiences, the children argue for different reasons behind animal diversity. More specifically, the children's discussions concerned four conceptual themes: animals are different because of kinship and heredity, environmental effects, the need for adaptation, and the need for geographic separation.

Through inductive coding, the materials' function was analysed by focusing on which materials were used and how they were used in specific situations. The analysis of the materials' functions reveals that there are three different ways in which the children used the provided materials; namely, as resources providing meaning, as argumentative tools, and as communicative tools.

Without having received any formal instruction on evolution, the children spontaneously discussed similarities and differences in traits by making observations in a logical and scientific way. Thus, the results imply that variation might be a fruitful way to introduce evolution theory to children in preschool class.

Paper II: When Children Do Science: Collaborative Interactions in Preschoolers' Discussions about Animal Diversity

In this paper, relationships between acts of doing science (Lemke, 1990) and collaborative interactions (Granott, 1993) are explored. Video data from four small-group discussions (N=14) was analysed using Lemke's (1990) talking science framework and Granott's (1993) collaborative interactions framework.

The findings of this paper reveal that the children make use of their prior experiences and the materials provided as they engage in acts of doing science in small-group discussions. Moreover, the results show that preschool class children can engage in science dialogue as they use observations and comparisons as data to generate, describe, and discuss ideas. While engaged in highly collaborative interactions, the children use observations to evaluate, challenge, and question each other. Moreover, the paper provides insight into how acts of doing science can be discerned from children's discussions about evolution.

In addition, the study indicates that the character of the collaborative interactions is an important factor for how acts of doing science are carried out. More specifically, more acts of doing science are present in highly collaborative child–child interactions (mutual collaboration interactions) than in highly collaborative child–adult interactions (scaffolding interactions). Thus, the paper highlights that adults' actions and the dialogue between peers are important for how science is done. In sequences involving child–child interactions, the adult participant is less active and engages more in attentive listening than in sequences involving scaffolding, where the adult is more actively engaged in the dialogue. In mutual collaboration interactions, the children observe and compare materials on their own and in collaboration with each other. In turn, the

children use these observations to generate and evaluate ideas. As compared to approaches where teachers scaffold children in how they should perceive materials in order to enhance their science understanding, this study suggests that teachers taking the role of an attentive listener could enable aspects of science as a communal practice to emerge.

Overall, this study contributes with knowledge demonstrating that children as young as six years old can do science when engaged in science-related discussions.

Paper III: Children's Encounters with Natural Selection during an Interactive Read Aloud

This work contributes with knowledge about the role of the interactive read aloud as a pedagogical tool for introducing evolution in early childhood education.

The paper builds upon theories in which the meanings of storybooks are seen as interactively negotiated (Cochran-Smith, 1984). Several previous studies (Emmons et al., 2017; Emmons et al., 2016; Kelemen et al., 2014) have shown that children as young as five years of age are able to form a basic understanding of evolution after listening to a storybook about natural selection. In this paper, the same storybook is read using an interactive approach, which is representative of actual approaches in preschool educational practice. This study offers a semiotic exploration of what children focus on, and negotiate, during the interactive read aloud.

Video data from eight interactive read aloud sessions, with three children in each group, were analysed using a multimodal approach and contrasted with the seven biological concepts intentionally described in the storybook. The analysis reveals that all of these biological concepts were focused upon at some point during the read aloud. In addition to the biological concepts, other topics were focused upon as well. That is, the children also negotiated the following topics: *Death, Changes in behaviour, Realism, Babies, Milli bugs,* and *Aesthetics.* Furthermore, the children frequently initiated discussions about variation. These discussions target within-species variation, variation in access to food, and variation in health and death. One important aspect that might explain the high

prevalence of talk related to variation is that the children had a direct view of the book's pictures.

The children's meaning-making processes were influenced by "a child-centric view of life" throughout the interactive read aloud. For example, the children suggested that animals should help each other to survive, providing altruistic perspectives to the meaning making. The paper reveals that, when read in an interactive way, instructional storybooks are not purely instructional. That is, instructional storybooks also become tools for discussing topics that children find important.

Paper IV: Kneading a Pilose: What Meaning about Evolution do Children Transfer from a Storybook Read Aloud to a Modelling Task?

Following on as a companion study to that reported in Paper III, this paper contributes insight into how children's representational practices, and their transfer of understanding from a read aloud, influence their meaning-making processes during a modelling activity. Specifically, the study investigates how children transfer meaning about the evolutionary concepts from the storybook to the modelling task.

Immediately following the interactive read aloud, the children were videotaped while they produced a clay model, and explained how they thought a pilose would look if it lived in one of three (mountainous, snowy, forest) future environments.

The children's transfer of meanings during the modelling activity was studied through analysing the children's verbal and non-verbal actions while producing their pilose models. The seven biological concepts were used as codes for analysing how children transfer meaning about evolutionary concepts. An eighth concept, "Adaptation to environment", was added since it was frequent in the children's discussions. The findings revealed that, although the children exposed all eight evolutionary concepts during the modelling activity, there was distinct variation among the groups. The most commonly exposed concepts were "differences in health and survival due to differences in access to food" and "adaptation to the environment", while the concept "variation within a population" only emerged once.

The analysis also considered how the children's utterances were generated during the modelling process; for example, as emanating from direct questioning, in connection with the picture of the future environment, in connection with the storybook content, or in connection with their own pilose models. The findings reveal that the children tended to discuss how piloses were adapted to their environment during the beginning phases of the task, followed by how different pilose traits led to differences in health and survival. In addition, the emergence of evolution concepts was most common in direct relation to the children's modelled piloses.

Overall, the paper identifies factors that influence children's meaning making about evolution concepts when conveyed through narrative, as compared with previously reported approaches that were more structured. The results show that the act of modelling provides an engaging meaning-making platform for transferring understanding about evolution. However, concepts such as variation within a population appear challenging for children to identify in their meaning making about evolution in this context.

Results and Discussion

In this chapter, I outline and discuss the main findings about how different resources, such as teaching materials, task contexts, and interaction influence children's meaning making about evolution.

In the first three sections, I discuss how communicated science content affects the science focus in the tasks, how materials function as semiotic resources and influences on meaning making, and how interactive aspects of doing science in the meaning-making processes occur in the three tasks. The final section summarises how the character of the tasks influences children's meaning-making processes.

Communicated Science Information Affects whether There Is More or Less Emphasis on Science in the Tasks

All four papers included in this thesis shed light on the science focus in the participating children's meaning making about evolution. In this section, I present two examples in which the children express meanings related to the evolution of species. The examples are chosen because they demonstrate the wide range of meanings made by the children in the research overall. The first example is from the group discussion and the second is from the modelling task. Although the tasks have similar characteristics – both are group-based, and the children have access to concrete materials – they differ in the communicated science content preceding them. That is, the children in the group discussion have not obtained any information on speciation or other evolutionary mechanisms, whilst the children participating in the modelling activity have received conceptual input from the storybook *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017).

In the group discussions, the children discuss reasons for animal diversity. The question posed for discussion ("Why are big cats different?") is rather open, and the children sometimes made meanings that were not "scientifically correct". The following excerpt provides an example of meanings generated in the group discussion:

Excerpt 1. Martin's reasoning during the group discussion task. Line numbers are shown in the left-hand column. Non-verbal communication is shown within parentheses.

1	M:	Erm... I was thinking like this, that at first, they were the same tigers
2		with sharp teeth (holds his index fingers at each side of his mouth)
3		really sharp, like this (pulls index fingers down across his chin) that
4		went down. So they could eat very well. And then, the snow leopard it,
5		it walked to the snow and started to get cold. Because it didn't find any
6		food and so. And then it [the snow leopard] became really snowy and
7		became a snow leopard. And the others... they walked to warmer and it...
8		like the tiger (points on the photograph of the tiger) it, it went
9		(points at the photograph again) to the forest and eats a lot of leaves

In the excerpt above, Martin tells his peers his idea that first animals have become geographically separated and then have eaten different food. Thus, the conceptual theme discussed here is *environmental effects*. That is, Martin claims that the cats have developed different traits because of living in habitats with different conditions. In Martin's reasoning, both climate (line 5) and food range (line 9) are brought up. However, in terms of "science focus in the meaning making", the scientific reasoning is rather vague. As described in Chapter 4, my role in the group discussions was passive, in terms of not participating in any teaching role. Consequently, the children did not receive any communicated science content regarding evolution preceding the discussion, nor was this provided during the discussion. Instead, the group discussion task was designed to allow the children to engage their previous experiences as part of their meaning making.

In the second data collection, the children received conceptual input through listening to the storybook *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017). In the subsequent modelling activity, the children drew on the storybook in their reasoning about how their piloses developed. Sometimes the children talked in a way that echoed the storybook's explanations of the evolution of the piloses' skinny trunks. For example, the children said that their pilose had a specific feature because its mum or dad "had that". Occasionally, the children also made explicit references to the book. The following excerpt includes both implicit and explicit references to the storybook. The chil-

dren in this group have received the mountain environment as their future environment. At the end of this group's modelling process, I ask Carl why his pilose has long legs.

Excerpt 2. Carl (C), John (J), and Johanna (R) during the modelling activity. Non-verbal actions are described within parentheses. Clarifications are made within square brackets. Links to images are shown in bold.

1	R:	If we think that the piloses look like this now (points at the NP). And in
2		the future, they look like this (points at Carl's pilose). How come they
3		look like this in the future?
4	C:	Because they might have longer
5		bodies, so they can get up in the
6		mountains like this (makes crawling
7		gestures with his arms). To get up like
8		this (stretches out both arms).
9	R:	So they can climb?
10	C:	Because here [in the mountains] there
11		are (looks and points at the NE) a lot
12		of knobs. **(Image 1)**
13		They can stretch like this (stretches
14		out his arms and upper body)
15		like upwards. (**Image 2**)
16	J:	Now I need more clay.
17	R:	(To C) How did that come to happen
18		then? The piloses living here (points
19		at the NPs on the NE), don't have
20		long legs (makes a similar crawling
21		gesture as Carl did) to climb with. But
22		this one (points at Carl's pilose) does.
23		How did that happen?
24	C:	Maybe it has… what's it called… maybe it has grown. Then… (places
25		his hand next to his mouth). Hmmm… I need to think. Maybe they
26		have… If they have long [legs] here and its [his pilose] mum and dad had
27		long legs so it [his pilose] had the same so it could climb up.
28	R:	So its [Carl's pilose] mum and dad had long legs?
29	C:	Mmm
30	J:	Mmm because I heard this in the book [*How the piloses evolved skinny*
31		*noses*] that piloses with small trunks (picks up an NP with a wide trunk)
32		will have small trunks their whole lives. And those [piloses] that have
33		long (points at an NP with a skinny trunk) and have children, they [the
34		children] will have long trunks.

Image 1

Image 2

Carl initially describes the long body of his pilose as a feature that enables the pilose to climb the mountains (lines 4–8, 13–15), and relates his pilose's feature to the environment (lines 10–12). In his description of his pilose, he embodies the pilose's climbing movements by stretching out his arms in a crawling gesture, illustrating that the pilose can stretch out its body. In this context, I interpret Carl's action to mean that his pilose has long legs (line 20), which Carl does not object to.

Carl's reasoning is in line with the conceptual theme *need for adaptation*, meaning that animals need different characteristics to survive in their habitat. However, as I continue to ask Carl about how the process behind the development of the feature in focus (lines 17–23), he says that the pilose's parents had long legs. This meaning is in line with the biological concept "The reliable transmission of heritable physical traits across generations", which is described in the storybook he had previously listened to.

In lines 30–34, John confirms Carl's meaning regarding the inheritance of traits by making an explicit reference to the storybook. John describes inheritance of traits and trait consistency in a way that is almost identical to how the book explains the biological concepts "The reliable transmission of heritable physical traits across generations" and "The stability and constancy of inherited traits over the lifespan". Thus, both John and Carl refer to the storybook in their reasoning. This indicates that the storybook serves as a resource in their meaning making. That is, even though the storybook is not physically present, the children draw on the book's science focus. In turn, the book's science focus serves as a powerful resource that influences the science focus in the children's meaning-making processes during the modelling activity.

Materials are Important Semiotic Resources that Affect Children's Meaning Making about Evolution

In all the tasks, the children were provided with materials; namely, photographs, figurines, and a world map (group discussion); the storybook *How the piloses evolved skinny noses* (Kelemen & The Child Cognition Lab, 2017) (read aloud); and photographs, clay, and premade piloses (modelling activity). During the tasks, three different ways of using the

materials as semiotic resources were discovered. The following paragraphs provide examples of how the materials were used and how this use influenced the meaning-making processes during the tasks.

During interaction, the children used the materials as *communicative tools*. For example, they pointed to the materials and used them as a shared reference point (Tytler et al., 2007). In turn, using the materials as communicative resources enabled the children to express and discuss their meanings.

In the group discussion, the materials also served as *argumentative tools*. That is, the children used observed aspects of the materials to argue for their meanings. For example, Vanessa, Leah, and Emma repeatedly pointed out similarities and differences in pattern and size among the figurines as they argued which animals were more closely related than others (see the appendix in Paper II). Another example of using the materials as argumentative tools is found in a discussion where Sarah and Max argue about the meaning that animals need to live in certain habitats, otherwise they will die:

Excerpt 3. Max's (M) and Sarah's (S) interpretation and use of the map as an argumentative tool during the group discussion task. Clarification notes are provided within square brackets. Non-verbal communication is provided within parentheses. Links to images are shown in bold.

1	M:	The penguins live here [the
2		Antarctic]. It [the snow leopard]
3		could live here, too (takes the snow
4		leopard from Greenland and puts it
5		on the Antarctic). (Puts the lion on
6		the Antarctic.) If it lived here (makes
7		a guttural sound) it would die (lies
8		the lion down on one side).
9		(**Image 3**)
10	S:	(Smiles and points at Africa)
11		(**Image 4**) Because it should live
12		there.

Image 3

Image 4

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In the excerpt above, Max and Sarah interpret the different colours of the map as meaning either a hot or cold climate. That is, the map serves as a *resource providing meaning*. The children also acknowledge variation among the big cats and their needs (i.e. the lion needs to live where it is warm). Their interpretation of the map affects their meaning making. In turn, the map serves as an argumentative tool as the children make meanings by inferring that animals will die if they are placed in an environment where they should not live.

The materials sometimes directed the children to make certain meanings related to habitat differences as essential for evolution. As shown in the excerpt above, the children used the map as a resource providing meaning about climate. The photos given in the group discussion task and the modelling task also provided specific meanings for the children about habitat and climate. For example, the photograph of the tiger in the jungle implies that tigers live where there are a lot of leaves to eat (Excerpt 1) and the photograph of the mountain environment can trigger meaning making about piloses having to climb to find food (Excerpt 2).

Previous Experience Affects Children's Interpretation of Materials

Despite being provided with the same materials, the children participating in the respective tasks did not make identical meanings. This highlights that children observe different aspects, depending on the context and their previous experiences (cf. Van Leeuwen, 2005).

The observation that the children's previous experiences influence their use of the materials also became important in the interactive read aloud. The following excerpt shows that, when the children listened to the book, they drew on previous experiences as they negotiated the text and pictures. In the excerpt, the storybook communicates the biological concepts "Differential health and survival due to differential access to food" and "The reliable transmission of heritable physical traits across generations".

Excerpt 4. Johanna (R), Ellie (E), and David (D) during the interactive read aloud. The storybook's text is shown in italics while interactions outside the text are written in normal font. Clarification notes are provided within square brackets. Non-verbal communication is provided within parentheses. Links to images are shown in bold. Overlapping actions are shown by a handle in the left-hand margin.

1	R:	*Some piloses with wider trunks were*
2		*very weak and ill[18].*
3	E:	(points at two piloses that are lying
4		down) (**Image 5**)
5		That one's ill and that one's ill.
6	R:	Yes. *They died before having any*
7		*children. But other piloses with wider*
8		*trunks were only healthy enough to*
9		*have one child.* Do you see here
10		(points at two adults with wider trunks
11		that have one child each) that the wider
12		trunked piloses only have one child?
13	E:	(leans forward) Mmm, how cute they
14		are.
15	R:	*And that child was born with a wider*
16		*trunk* (points at a child with a wider
17	D:	Oh... (sounds sad and places his head
18		in his hands)
19	R:	trunk) *because its parents were born*
20		*with wider trunks.*
21	D:	So they [the children with wider
22		trunks] could have died too. (**Image 6**)

Image 5

Image 6

As the storybook's text communicates that some wide-trunked piloses died and some were able to only have one child, which also had a wide trunk, David reaches the conclusion that the children could have died too (lines 21–22). That is, David links wider trunks to death. However, his verbal and non-verbal communication also reveals emotional engagement in relation to his conclusion that wider-trunked children might die. Therefore, in these turns, the storybook is not restricted to being a resource providing scientific meaning about inheritance and survival. Due

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[18] In the original English text "and ill" was not stated. However, this was added to the Swedish version of the text.

to David's previous experiences of dying as "something sad", the story-book also provides meaning that affects him emotionally.

Nature of the Interaction Affects how Science is Done

All the tasks included in this thesis were carried out in interaction between the children and between the children and me. Paper II highlights that the character of the interaction seemed to have an impact on how acts of doing science (Lemke, 1990) were carried out. That is, in interactional sequences characterised by mutual collaboration, the children performed more acts of doing science compared to interactional sequences characterised by scaffolding or symmetric counterpoint.

The modelling task was more individual, even though it was carried out in groups, while the group discussion task did not have an individual focus. In the group discussion task, most interactional sequences were characterised by mutual collaboration (12 out of 22 interactional sequences). Nine were characterised as scaffolding and one was characterised by symmetric counterpoint. In comparison, almost all the interactional sequences in the modelling activity and the read aloud were characterised as scaffolding interactions. The differences in the character of collaborative interactions in the different tasks are related to my actions during the tasks. That is, in comparison to the group discussion, I was more active in explaining things and instructing the children during the modelling activity and the interactive read aloud. Moreover, during the modelling activity, I reminded the children about the book. Consequently, during that activity, the children's science focus and the dialogue were more directed compared to the group discussion task.

When analysing the interaction in the read-aloud sessions, the most common acts of doing science were describing and observing. For example, the children observed and described the images in the book. One example of this is shown in Excerpt 4, where Ellie follows the story and points out piloses that she sees as "ill" (lines 3–5). However, the children also occasionally questioned and challenged the book. For instance, they suggested that piloses should alter their behaviour to survive. For example, the children suggested that the piloses should dig for milli bugs instead of just using their trunks. Furthermore, some children reasoned in an altruistic way, claiming that the piloses should help each other. The

children's suggestions about how to solve problems can be seen as reflecting a "child-centric" view of life inherent in the notion that if there is a problem, you try and solve it.

In the modelling task, most children engaged in doing science by observing and describing the given future environment depicted in their photographs and describing the development of their crafted pilose. Sometimes the children questioned each other and the choices their peers made regarding colour and form. Furthermore, the children also occasionally elaborated upon what (an)other child(ren) had said. However, compared to the interactions in the group discussions, fewer acts of doing science were carried out in the modelling activity. One explanation for this could be that the modelling task was more individual compared to the group discussion. That is, in the modelling task, each child crafted his/her own pilose, while the group discussion engaged the children in collaboratively discussing their ideas regarding animal diversity. In the following section, findings regarding the task contexts and how they influenced the children's meaning making are further described and discussed.

The Task Context Affects the Meaning-Making Processes

The children's meaning making about evolution was affected by the different characters of the tasks. This is considered in more detail in the following.

The group discussion task was characterised by an open question and mutual collaboration. Consequently, the children carried out multiple acts of doing science and used the materials not only as communicative resources and as resources providing meaning, but also as argumentative tools. However, due to the lack of communicated scientific content, the science focus in the meaning making sometimes diminished.

The read aloud, albeit interactive, was much more scripted than the group discussion task. The collaborative interaction in the read aloud was characterised by scaffolding. The children used the images in the book mainly as communicative resources and as resources providing meaning. Fewer acts of doing science were carried out in comparison to the group discussion. The science focus, evolution through the process of

natural selection, was emphasised. However, the children also put forward a child-centric view of the story by engaging their previous experiences.

The character of the modelling task had similarities with both the group discussion and the read aloud. More specifically, the modelling task shared the openness of the group discussion but also the science focus that originated in the read aloud. Consequently, as in the group discussion, "scientifically incorrect" meanings emerged during the modelling activity. However, most of the children were clearly influenced by the preceding read aloud and referred to the storybook in their reasoning. Due to the less collaborative task, fewer child–child interactions occurred. Furthermore, fewer acts of doing science were carried out in the modelling task in comparison to the group discussion task.

General Discussion

In this chapter, I discuss the findings presented in Chapters 5 and 6. In doing so, the scientific contribution of the thesis is outlined.

Meaning Making is Complex

This thesis contributes with new perspectives on children's meaning-making processes about evolution. Specifically, it provides empirical evidence of how children draw on materials as semiotic resources in their meaning making about evolution. The findings also show that how tasks are designed has an impact on children's interactions and how science is done.

Many studies have shown that the theory of evolution is difficult to understand, not only for young children (e.g. Berti et al., 2017; Berti et al., 2010; Evans, 2000; Samarapungavan & Wiers, 1997), but also for older students (e.g. Ferrari & Chi, 1998; Shtulman, 2006) and adults (e.g. Nehm & Reilly, 2007; Prinou et al., 2011; Spiegel et al., 2006). Researchers have made several attempts to find ways to teach evolution to young children. For example, children have been taught about evolutionary mechanisms through playful games (Campos & Sá-Pinto, 2013), computer games (Horwitz et al., 2013), hands-on activities (Nadelson et al., 2009), and storybooks (Browning & Hohenstein, 2015; Emmons et al., 2017; Emmons et al., 2016; Kelemen et al., 2014). In summary, this research has shown that children as young as five years old are able to learn simplified versions of multiple evolutionary concepts. However, meaning making is a complex process. In this thesis, I have attempted to understand the meaning-making processes occurring when children encounter evolution in different tasks. The idea is that, if researchers and teachers can understand what affects children's meaning-making processes, fruitful and meaningful activities for introducing evolution to children of preschool class age (6-year-olds) can be developed. This does not mean that I believe there is one universal way of teaching evolution. There is no method, task or activity that will enable all children to grasp the whole theory of evolution. However, by gaining insights into how different resources such as materials and tasks influence meaning making,

researchers and teachers can gain a better understanding of how to stimulate meaning making.

Young Children Can Make Meaning about Abstract Scientific Phenomena

The findings of this thesis show that, when children are provided with materials to use as semiotic resources, they can discuss abstract science phenomena in different types of tasks. In turn, these findings highlight that materials are important tools in children's meaning-making processes and have an impact on what they are able to discuss (Schoultz et al., 2001).

Three of the conceptual themes emerging in the group discussion task and then applied in the read aloud and the modelling activity – namely environmental effects, the need for adaptation, and the need for geographic separation – relate to the environment and environmental differences between the habitats where animals live. That is, animal diversity is linked to their habitats in some way. In turn, these three themes do not include reasoning about how changes in features occur. Nevertheless, the children discuss how changes in features happen in relation to the conceptual theme of kinship and heredity. In the group discussion, talk about inheritance occurred, but not very often. However, in the modelling task, the children repeatedly talked about their pilose's development in terms of having inherited focused features (e.g. Carl's pilose has long legs because its parents had long legs). The science content negotiated in the interactive read aloud of the storybook is thus a resource supporting the children in reasoning about evolution as a process that includes variation, reproduction, and selection.

Recent literature (Nadelson et al., 2009) suggests that evolution cannot be taught to young children in the same manner as to older students. Some researchers suggest that children need strict frames (Emmons et al., 2016; Kelemen et al., 2014) or guidance from teachers (Nadelson et al., 2009)[19] in order to learn about evolution. In this thesis, the children were engaged in three different types of tasks. These tasks range from

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[19] See also Bergnell (2019) regarding the promotion of teacher guidance in preschool children's interpretations of science representations.

open (group discussion and the modelling activity) to more scripted (read aloud). The findings of this thesis reveal that children can discuss and make meaning about evolution during tasks where they do not receive a lot of guidance or communicated science content. However, *how* the children discussed the reasons for animal diversity and natural selection varied between the tasks.

In relation to previous research on children's understandings of evolution and evolutionary mechanisms, this thesis reveals three main differences. Firstly, all the children in this study actively took part in the tasks. Especially in the group discussion task and the read aloud, the children shared their ideas on evolution and the reasons behind animal diversity. This can be compared with Berti et al.'s (2017) study, in which many children gave "don't know" answers to questions about speciation and the origin of species before they had been taught about evolution. One reason for the high engagement in the group discussion here could be that the questions posed in the discussion task were often directed to the group as a whole. Consequently, the children participating in the discussion in a spontaneous way could build on each other's posed ideas and help scaffold one another's ideas (cf. Murphy et al., 2011). In addition, the question posed in the group discussion task was very open ("Why do big cats look different?"). Furthermore, these children had not obtained any information about speciation or evolution preceding the discussion. Therefore, the children in the group discussion might not have got the feeling that there was a "correct way of reasoning". Consequently, they were "free", as they only built their reasoning on their previous experiences and their use of the materials.

Secondly, previous research on children's understanding of evolution has suggested that they talk about the origin of species in a creationist way (e.g. Evans, 2000; Berti, 2010). In this study, there are no reported findings of explicit creationist reasoning among the children. However, this is not surprising, since Swedish children are often less exposed to religious views about the origin of species than children in other countries. This result again highlights the cultural dimension of children's reasoning about evolution (Berti et al., 2017).

Thirdly, in both the group discussion task and the interactive read aloud, children spontaneously engaged in discussions about variation; a cornerstone of the theory of evolution (Mayr, 1982). This is an intriguing

finding, since talk about variation has been hard to stimulate according to previous research (Emmons et al., 2017).

Understanding Preschool Class Children's Meaning-Making Processes When They Encounter Evolution

This work has investigated how different resources, such as teaching materials, task contexts, and interactions influence children's meaning making about evolution. In approaching the end of this text, I present three conclusions.

Firstly, preschool class children's meaning-making processes are affected by the teaching materials. More specifically, children use materials as resources that provide meaning. This means that the children draw on the meaning-making potential of the materials, a process that is influenced by their previous experiences. Moreover, in interaction with peers, materials also serve as communicative and argumentative tools. Thus, having access to materials enables children to discuss evolution. In turn, access to materials enables children to do science.

Secondly, there is an intimate relationship between task context and how interactions are characterised. These resources, the task context and the interaction, influence children's meaning-making processes. That is, the task context – being more or less open – affects the character of the interaction in the task. Less open/more scripted tasks contain more child–adult interaction in which the adult guides the children. These are referred to as scaffolding interactions. More open/less scripted tasks, where children build on previous experiences instead of communicated science content, stimulate mutual collaboration.

Thirdly, in scaffolding interactions, greater emphasis is placed on the science topic of the task due to the guidance from the adult. Consequently, meanings made by children in more scripted tasks are more likely to be "scientifically correct". However, if the teacher or the adult steps back and allows the children to engage in mutual collaboration, they can engage in multiple ways of doing science.

Implications for Research and Practice

This chapter describes the implications for research and school practice and suggestions for future research.

A Child-Centric View of Life Affects the Focus of the Tasks

The findings of this thesis reveal that children do not only focus on what natural scientists would call "science" in their meaning making about evolution. In the tasks, a child-centric view of life emerges in a salient manner. For example, the children discuss the idea that animals change as a direct consequence of environmental impact, such as the sun creating the animals' patterns or that an animal changes as a consequence of what it eats. These are not scientifically correct explanations. However, they are relevant assumptions based on the children's observations of the world and their own experiences of, for example, becoming tanned in the summer. Peters and Davis (2011) use the term *working theories* to describe similar ways in which children build on existing knowledge to make meaning about the world. The term child-centric view of life differs from working theories in that it acknowledges that, apart from the science focus, children also focus on other aspects that are relevant and important to them as they engage in science activities. For example, the findings of Paper III demonstrate that the children negotiate other aspects apart from the explicit evolution-related content of the storybook *How the piloses evolved skinny noses*. During the interactive reading, the children discussed topics such as death and altruistic ideas regarding the idea that animals should help each other out[20]. In addition, the findings of Paper IV show that the children's preoccupation on concepts associated with "big questions" (Gallas, 1995), such as "how to behave to survive", played a large part in determining their focus during the mod-

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[20] Robinson and Curry (2005) suggest that teachers can use storybooks to promote altruism in school.

elling task. This thesis thus provides evidence that children's participation in science tasks affects and elaborates upon what is the focus of the task.

Jakobson and Wickman (2008) have shown that children and their teachers in elementary school often make aesthetic judgements when engaging in science activities. For example, children express joy or displeasure, and react to things they find ugly or beautiful. Jakobson and Wickman argue that aesthetic experiences have consequences for children's further meaning making in science. In addition, in relation to the read aloud, third spaces, where everyday experiences and scientific explanations are linked together (Varelas et al., 2014), support meaning making by allowing children to take part in constructing the story and linking life to text (Cochran-Smith, 1984). In my view, the emergence of the child-centric focus during the tasks in this thesis is a strength. The children's focus and interest might be built upon by teachers in subsequent activities. In addition, the children's child-centric focus expressed through wonder and enjoyment, but also serious pondering about death can be seen as valuable in itself, since it can make children interested and motivated to engage in science activities (cf. Siry, 2014). Furthermore, the child-centric focus enables the children to participate and co-construct the focus of the activities (cf. Oyler, 1996).

When the Teacher Steps Aside, Children Engage in Doing Science

In this thesis, science is acknowledged as being more than merely conceptual knowledge. In addition, it is viewed as a communal practice that is done (Lemke, 1990; Siry, 2013; Siry et al., 2012). From this perspective, it is insufficient to conclude that children are able to talk about evolution or that they seem to express more scientifically correct explanations of evolution after they have listened to a story about evolution. That is to say, apart from the science focus of the children's meaning making, other aspects of the meaning-making processes that occur in the tasks are important too. I build upon Lemke's (1990) terminology and define doing science as several acts, such as describing, observing, comparing, elaborating, questioning, and challenging. As shown in Paper II, there

seems to be a relationship between mutual collaborations and the emergence of multiple acts of doing science. Mutual collaborations are in turn related to more open tasks where the adult, me, steps aside and provides space for the children to interact with each other[21].

Therefore, teachers and researchers trying to find ways to improve learning practices in science education should not be afraid to let children engage in discussions about science without interfering. Children are capable of more than just discussing abstract science topics. They can do science.

Balancing Doing Science and Conceptual Aspects of Science

Johnston (2009) raises the question of what will happen to children's opportunities to develop scientific skills, such as observation, explanation, and forming hypotheses, as the preschool context and primary school context shifts the focus towards the acquisition of conceptual knowledge. Science in Swedish preschool class practice balances learning "scientific content" and "doing science". In relation to the latter, my thesis contributes with the insight that, if we want children to do science, it might be more fruitful for the teacher to step back and not provide guidance (see the previous section). However, this means that the scientific content might be weakened. The burning question is: what is more important? Is it to provide children with opportunities to do science in terms of discussing, exploring, forming hypotheses, observing and so on, or is it to provide them with correct scientific conceptions which they can later build upon when they proceed with their education? Perhaps there is no need to choose a specific path. One way of dealing with the tension between doing science and pursuing correct conceptual understanding could be to provide children with enough "space" to do science in activities which also have a clear science focus. In this regard, Cowie and Otrel-Cass (2011) suggest that children can develop observational skills when they have the opportunity to build upon their previous experiences to develop ideas through observation, questions, and discussing science

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[21] In comparison, Johnston (2009) has shown that the context of a task (meaning the activity, the environment, and the resources (toys)) along with social interaction in the groups, affects children's demonstrated scientific skills.

phenomena. Moreover, storybooks, when read in an interactive way, are powerful tools that stimulate children's curiosity about science (cf. Oyler, 1996). In the interactive reading of storybooks about evolution, children can make meaning about topics relating to evolution. However, they also initiate other topics that they find relevant. Thus, an interactive read aloud creates a context for meaning making in science.

Materials Direct Children's Meaning Making

This thesis has shown that materials have different functions in children's meaning-making processes. By analysing what children do with materials – the function of the materials – we create the possibility to choose and provide materials that support children's meaning making. For example, if the goal is to direct their meaning making, it is a good idea to provide materials that can be used as resources that provide meaning. If speciation is the science focus, it is fruitful to provide materials that depict different environmental conditions (cf. the different habitats depicted in the photographs in the group discussion task). However, if we want children to engage in meaning making about inheritance, it is fruitful to provide them with experiences of cross-generation resemblances (cf. piloses with wide trunks have children with wide trunks).

Suggestions for Future Research

This study has provided knowledge about how specific materials function in specific tasks regarding a specific science topic: evolution. Further research can provide insight into whether these functions are valid when other science topics are the focus. In addition, future research could study how other teaching materials function as semiotic resources (e.g. digital tools) and how children use other modes of communication than those visible in this thesis (e.g. digital storytelling).

I have studied children's meaning-making processes in situated contexts. Therefore, it is not possible to discern whether or how the children's meaning-making processes continue after they have participated in the tasks. Future studies could investigate whether, and if so how, children's meaning-making processes continue after they have participated

in similar tasks. Furthermore, future research could explore how children who have had an early encounter with the theory of evolution reason about evolution as they finish compulsory school.

In this thesis, I have used three theoretical lenses to study meaning making about evolution. Future research could develop this approach in pursuing a coherent theoretical framework for studying children's meaning making in science more generally.

Svensk sammanfattning

I det här kapitlet sammanfattas avhandlingens bakgrund, teoretiska- och metodologiska ansats och resultat på svenska.

Bakgrund

Avhandlingen utforskar de meningsskapandeprocesser som äger rum när förskoleklassbarn deltar i gruppbaserade aktiviteter som handlar om evolution.

Evolution är väldigt komplext. Därför menar vissa forskare (t.ex. Berti et al., 2017) att denna del av biologiundervisningen borde vänta tills barnen är i tioårsåldern. Andra forskare (t.ex. Gallas, 1995) menar emellertid att barn redan i yngre år är nyfikna på så kallade "stora frågor", det vill säga frågor om exempelvis livet och döden, hur barn blir till, var rymden tar slut och så vidare. Evolution och det faktum att allt liv på jorden är besläktat med varandra är också en "stor fråga". Barnen som deltar i den här studien är sex år och går i förskoleklass. Jag sällar mig till dem som menar att barn i den här åldern inte alls är för små för att prata om evolution. Däremot kan vi inte prata om evolution med sexåringar på samma sätt som vi pratar med högstadieelever eller med vuxna.

Det finns en hel del forskning som visar att både barn (t.ex. Berti et al., 2017; Berti et al., 2010; Evans, 2000; Samarapungavan & Wiers, 1997) och vuxna (t. ex. Nehm & Reilly, 2007; Prinou et al., 2011; Spiegel et al., 2006) har svårt att förstå och prata om evolution på ett naturvetenskapligt sätt. Många försök har gjorts att skapa olika läraktiviteter eller interventioner med syfte att lära barn som evolution. Bland annat har barn undervisats genom olika lekfulla spel (Campos & Sá-Pinto, 2013), datorspel (Horwitz et al., 2013), skapandeaktiviteter (Nadelson et al., 2009) och genom högläsning av böcker som handlar om hur arter utvecklas (Emmons et al., 2017; Emmons et al., 2016; Kelemen et al., 2014). Sammantaget pekar denna forskning på att barn redan i femårsåldern kan förstå, i alla fall vissa aspekter av, evolution.

Studiens kontext: Förskoleklassen

Förskoleklassen är en svensk skolform som ligger mellan förskolan och årskurs ett. Förskoleklassens verksamhet har likheter med både skolans och förskolans praktik. Förskoleklassen kan alltså beskrivas som en "mellanklass" (Lago, 2014) där förskolans lekbaserade praktik och lekmaterial kombineras med grundskolans undervisningstradition. Förskoleklassen utgör därför en intressant praktik för att utforska nya sätt att introducera evolutionsteori för barn.

Avhandlingens syfte

Syftet med den här avhandlingen är att utforska vad det är som påverkar barns meningsskapande. Mer precist undersöks hur olika resurser, som material, uppgifters kontext och interaktion, påverkar barns meningsskapande om evolution.

Genom att studera meningsskapande om evolution som en process, bidrar avhandlingen med insikt om viktiga aspekter i relation till hur lärare kan arbeta med naturvetenskap i allmänhet och evolutionsteorin i synnerhet.

Meningsskapande som teoretiskt ramverk

I den här avhandlingen utgår jag ifrån sociokulturella och socialsemiotiska perspektiv på kommunikation och meningsskapande. I huvudsak används tre teoretiska linser. Dessa är: 1) Naturvetenskapligt fokus i meningsskapande, 2) materials funktion som semiotiska resurser och 3) interaktiva aspekter av meningsskapande. Dessa tre teoretiska linser kommer strax beskrivas mer ingående, men först kommer jag förklara vad som menas med begreppet meningsskapande, att naturvetenskap är en social praktik och att kommunikation är multimodal.

Meningsskapande är det som sker när idéer och tankar bearbetas. Meningsskapande en kontinuerligt pågående process, vi skapar alltså mening hela tiden, både på individnivå och i interaktion med andra (Mortimer & Scott, 2003).

På samma sätt som *mening* är något som *skapas* (Lemke, 1990), är naturvetenskap (på engelska "science") något som *görs*. Naturvetenskap är alltså inte bara en uppsättning fasta begrepp och teorier, utan det in-

begriper också mänsklig aktivitet. Genom att använda material och interagera med människor skapas naturvetenskap (Ash, 2004; Siry et al., 2012).

Flera handlingar (engelska: acts) inkluderas i begreppet "att göra naturvetenskap". Barn gör naturvetenskap när de exempelvis beskriver något, observerar, jämför olika saker, ställer hypoteser, ifrågasätter och så vidare (Lemke, 1990). Vad som är viktigt här, är att "att göra naturvetenskap" är en social process. Det betyder att barns förståelse för naturvetenskap genereras och uttrycks i interaktion med andra (Siry et al., 2012). Därför är naturvetenskap en social praktik.

När jag i den här avhandlingen skriver om interaktion eller kommunikation, menar jag multimodal interaktion och kommunikation. En modalitet är något vi använder för att kommunicera. Till exempel kan både blickar, gester och talat och skrivet språk kommunicera något. Multimodal kommunikation och interaktion innebär att flera modaliteter är inblandade. Den som vi interagerar med, tolkar alla våra uttryck som ett gemensamt meddelande (Goodwin, 2000; Jewitt, 2011, Lemke, 1993).

Naturvetenskapligt innehåll i meningsskapande

I den här avhandlingen använder jag *mening* (engelska: meaning) som begrepp för att beskriva en idé eller någonting som rör det naturvetenskapliga innehållet (evolution) och områden som relaterar till evolution (exempelvis variation, ärftlighet, naturligt urval).

Som tidigare beskrivits, kan mening uttryckas med flera olika modaliteter. För att fånga barns meningsskapande kring evolution behöver jag tolka vad de uttrycker. I interaktion med andra, kan samma sak uttryckas på olika sätt. Dessa olika sätt att prata om samma sak bildar ett slags mönster, vilket kallas *thematic patterns* (Lemke, 1990). Ett thematic pattern kan alltså förstås som den gemensamma nämnaren i ett samtal. I den här avhandlingen ses den gemensamma nämnaren som de meningar som skapas när barn deltar i aktiviteter som handlar om evolution.

Materials funktion som semiotiska resurser

Semiotiska resurser har en viktig roll i allt meningsskapande. Semiotiska resurser är saker vi gör och saker vi använder för att kommunicera (Van Leeuwen, 2005). Alltså är verbalt och icke-verbalt görande, så som att tal

och pekningar, semiotiska resurser. Men även materiella ting – saker – kan användas som semiotiska resurser om dessa får en betydelse i meningsskapandet. Vägskyltar och emojis är två exempel på semiotiska resurser.

I relation till naturvetenskapsundervisning, finns det flera studier som pekar på hur användning av material som semiotiska resurser blir viktiga i barns meningsskapande. Exempelvis har Schoultz et al. (2001) visat att barnen har betydligt lättare att prata om varför människor "på undersidan" av jordklotet inte ramlar av jordklotet när de har tillgång till en jordglobsmodell, än när de inte har det. Vidare har Wilson och Bradbury (2016) lyft fram att barn syntetiserar information från flera olika material, så som fotografier och videos, när de skapar mening kring venus flugfällor (ett slags köttätande växt).

Semiotiska resurser är socialt och kulturellt betingade (Van Leeuwen, 2005). Det gör att ett material får olika meningspotential beroende på hur materialet använts tidigare, men också beroende på vilken kontext materialet befinner sig i och individers tidigare erfarenheter. Olika barn, och barn och deras lärare, kan därför tolka lärandematerial på olika sätt. Detta kan förklaras med att barn och vuxna har olika erfarenheter och därför "ser" (Säljö & Bergqvist, 1997) olika saker i material.

Interaktiva aspekter av meningsskapande

Den här avhandlingen undersöker barns meningsskapande när de deltar i gruppbaserade aktiviteter. Därför studeras interaktion som en aspekt av meningsskapandeprocessen.

Jag använder Granott's (1993) interaktionsmodell för att analysera och karaktärisera interaktionssekvenser. Modellen innehåller två dimensioner: Nivå av interaktion (måttlig-hög) och nivå av kunskap mellan deltagarna i interaktionen (symmetrisk-asymmetrisk). I den här avhandlingen återfinns tre olika typer av interaktion: Mutual collaboration, scaffolding och symmetric counterpoint. Dessa olika typer av interaktion kommer jag nu beskriva mer utförligt.

Mutual collaboration betyder att deltagarna i en interaktion är engagerade och att de ligger på ungefär samma nivå kunskapsmässigt. I interaktioner av den här typen avbryter deltagarna varandra, fyller i varandras meningar eller pratar i munnen på varandra. Deltagarna följer varandras resonemang och delar på det material som finns att tillgå.

I scaffolding-interaktioner är kunskapen asymmetrisk. Det finns alltså någon eller några som "kan mer" om det som interaktionen kretsar kring. Ett typexempel på scaffoldinginteraktioner är när lärare stöttar sina elever att lösa ett problem. Den som stöttar, leder den som blir stöttad genom att sätta fokus på centrala saker för meningsskapandet genom att exempelvis ställa frågor.

Symmetric counterpoint innebär att deltagarna i en interaktion ligger på samma kunskapsnivå, men samarbetet i interaktionen är inte lika framträdande som i mutual collaboration-interaktioner. Istället för att avbryta varandra och fylla i meningar, talar och lyssnar deltagarna på varandra i tur och ordning. Interaktionen karaktäriseras därför snarare av att alla säger sin mening, än att meningar samkonstrueras.

Metoder för datainsamling och analys

Aktiviteter och datainsamling

För att undersöka barns meningsskapande processer, har tre olika aktiviteter designats och genomförts. De tre aktiviteterna är följande: en *gruppdiskussion* kring hur det kommer sig att arter är olika, en *interaktiv högläsning* (Oyler, 1996) av en bok som handlar om hur en fiktiv djurart, pilosar, utvecklat en speciell egenskap (en smal snabel) och en *modelleringsaktivitet* där barn skapar en egen pilos i lera i relation till en tilldelad miljö. Alla aktiviteter genomfördes i grupper om tre-fyra barn och är filmade i sin helhet med två kameror. 27 förskoleklassbarn deltar i gruppdiskussionen och 40 barn i de två andra aktiviteterna.

I den första aktiviteten har barnen inte fått någon undervisning kring evolution eller evolutionära processer, utan de bygger på sina tidigare erfarenheter. I de andra två aktiviteterna tar barnen del av naturvetenskapliga förklaringar om evolution genom att de lyssnar på en barnbok. Barnboken som lästes för barnen heter "Hur pilosarna utvecklade sina smala snablar" (Engelska: "How the piloses evolved skinny noses"). Boken är skriven av en amerikansk forskargrupp och har som syfte att lära barn hur evolution genom naturligt urval går till (Emmons et al., 2016).

Boken har stora bilder som tillsammans med bokens text beskriver bokens innehåll. I boken förklaras naturligt urval utifrån sju olika biologiska begrepp:

1. Variation inom en population,
2. Förändring i habitat och tillgång till föda som en konsekvens av klimatförändringar,
3. Skillnader i hälsa och överlevnad som en konsekvens av olika tillgång på föda,
4. Skillnader i reproduktionsförmåga på grund av varierande hälsotillstånd,
5. Drag ärvs genom generationer,
6. Ärvda drag är stabila och förändras inte under en individs livslängd,
7. Anpassning sker över flera generationer.

I samtliga aktiviteter har barnen tillgång till material som skulle kunna användas som semiotiska resurser i deras meningsskapande. I gruppdiskussionen har barnen tillgång till en topografisk världskarta, fyra verklighetstrogna leksaksdjur, ett lejon, en tiger, en snöleopard och en jaguar, och fotografier som visar samma djur i deras respektive habitat. I den interaktiva högläsningsaktiviteten gör placeringen av barnen och boken det möjligt för barnen använda sig av boken som semiotisk resurs. I modelleringsaktiviteten har barnen förutom lera, tillgång till fotografier som visar en "framtidsmiljö", fotografier på hur miljön såg ut "förr" (dvs. i den tid som boken utspelar sig) samt fyra lerfigurer som avses se ut som pilosarna i boken.

Analysmetod

Både verbal och icke-verbal kommunikation transkriberats och analyserats. I de exempel som används för att illustrera resultaten, används ibland bilder för att synliggöra ickeverbal kommunikation och användning av material.

Avhandlingen består av fyra artiklar och en kappa. I arbetet med avhandlingens kappa har några exempel ur data om-analyserats för att på så vis undersöka hur olika kontexter påverkar meningsskapandeprocessen. I analysen används flera olika analytiska verktyg, vilka nu kommer beskrivas.

Meningsskapandeprocessens naturvetenskapliga fokus har analyserats på två sätt. För det första har mening analyserats utifrån de konceptuella teman som framkom i artikel I rörande hur barn förklarar bakomliggande orsaker till artbildning. Dessa är: Djur är olika för att 1) de är släkt med varandra på olika sätt och ärver olika drag (Släktskap och ärftlighet), 2) De har blivit påverkade av faktorer i miljön, exempelvis kan de ha ätit något som förändrat dem (Miljömässig påverkan), 3) Djuren lever på olika platser med olika förutsättningar och måste anpassa dig till detta för att överleva (Behov av anpassning) och 4) Eftersom djuren är olika och har olika behov, måste de bo på olika platser (Behov av geografisk separation). För det andra har data ur högläsningsaktiviteten och modelleringsaktiviteten analyserats utifrån de sju biologiska begrepp som tas upp i barnboken som barnen lyssnat till.

I artikel I framkommer att barnen använder material på tre olika sätt, som kommunikativa redskap, argumentativa redskap och som meningsgivande resurser. I kappan appliceras dessa funktioner i samtliga exempel för att belysa hur material påverkar barns meningsskapande.

Interaktiva aspekter av meningsskapandeprocessen har analyserats med hjälp av Granotts (1993) ramverk och Lemkes (1990) begrepp för att "göra naturvetenskap".

Avhandlingens resultat och implikationer

Avhandlingens resultat visar att de deltagande barnens meningsskapandeprocesser påverkas av att de tagit del av naturvetenskapliga förklaringar kring evolution. De barn som deltar i gruppdiskussionen bygger sina idéer på sina egna erfarenheter och användningen av materialet som meningsgivande resurser. Detta medför att de meningar som uttrycks inte alltid är naturvetenskapligt "korrekta". De barn som först lyssnat på barnboken bygger tydligt på de förklaringsmodeller som presenteras i den. Exempelvis pratar barnen i modelleringsaktiviteten om att deras pilos har ett visst drag (ex. långa ben) för att "dens mamma hade det".

I relation till att göra naturvetenskap i de olika aktiviteterna, visar dock analysen att barnen gör *fler* naturvetenskapliga handlingar i gruppdiskussionen än vad de gör i de två andra aktiviteterna. En förklaring till detta kan vara att gruppdiskussionen har en mer öppen karaktär och att min roll som vuxen inte är lika framträdande i diskussionen. I de andra

två aktiviteterna har jag en mer framträdande roll som lärare, exempelvis ställer jag fler frågor och påminner barnen om bokens innehåll. Högläsningen och modelleringsaktiviteten karaktäriseras således av scaffolding (Granott, 1993). Det finns alltså ett samband mellan aktiviteternas utformning, interaktionens karaktär, hur naturvetenskap görs och tyngdvikten vid naturvetenskapliga förklaringar av evolution.

Avhandlingens resultat visar också att material är viktiga och har olika funktioner som semiotiska resurser i barnens meningsskapande. Möjligheten att använda material gör att barnen faktiskt kan prata om abstrakta fenomen som variation och hur evolution går till (jmf. Schoultz et al., 2001). I gruppdiskussionen används materialet både som kommunikativt redskap, argumentativt redskap och som meningsgivande resurs. I de andra två aktiviteterna återfinns dock bara funktionen som kommunikativt redskap och meningsgivande resurs. Att barnboken och materialet i modelleringsaktiviteten inte används som argumentativt redskap kan även det relateras till uppgifternas utformning. Högläsningen och modelleringsaktiviteten är mer styrda och barnen har dessutom fått en naturvetenskaplig förklaring till evolution presenterad för sig. Därmed kan barnen i dessa aktiviteter känt att det redan finns "ett rätt svar", vilket i sin tur kan ha resulterat i att barnen inte argumenterar för sina idéer i samma utsträckning som de barn som deltar i gruppdiskussionen. Vidare medför inramningen av uppgifterna att barnen interagerar olika mycket med varandra. I gruppdiskussionen ombeds barnen att diskutera sina idéer med varandra, medan modelleringsaktiviteten är mer individuellt inriktad eftersom barnen skapar varsin modell och sen resonerar utifrån den.

Ett viktigt resultat av den här avhandlingen är att även om barnen resonerar mer naturvetenskapligt i de båda aktiviteterna som knyter an till barnboken, påverkas meningsskapandeprocesserna även av barnens syn på världen. Exempelvis uppmärksammar barnen andra aspekter i boken än de som är relaterade till de biologiska begreppen (se tidigare avsnitt). Barnen pratar exempelvis om döden, om att pilosarna ska hjälpa varandra att få mat och om att pilosarna skulle kunna göra på ett annat sätt för att få i sig mat (exempelvis gräva efter millibaggar istället för att bara använda sina snablar). Vidare påverkas barnens meningsskapande kring boken av deras egna erfarenheter och barnen uttrycker känslor i

relation till berättelsen. Barnens egna bidrag i form av fokus för meningsskapande och känslomässiga yttringar är betydelsefulla på minst två sätt. För det första har lärare möjlighet att bygga vidare på barnens intressen och på så vis skapa nya aktiviteter för meningsskapande inom naturvetenskap (jmf. Cowie & Otrel-Cass, 2011). För det andra är de känslomässiga yttringarna i form av glädje, men också sorg kring att djur dör, värdefulla i sig själva eftersom känslomässiga kopplingar bidrar till intresse och motivation till att lära sig mer (Jakobson & Wickman, 2008; Siry, 2014)

Avhandlingens bidrag

Den här avhandlingen bidrar med nya perspektiv på barns meningsskapande kring evolution. Avhandlingen visar empiriskt vilken funktion material har i barnens meningsskapandeprocesser. Vidare visar avhandlingens resultat på att aktiviteters olika karaktär påverkar hur barn gör naturvetenskap.

Meningsskapandeprocesser är komplexa. I den här avhandlingen har jag försökt utforska vad som påverkar meningsskapandeprocesser när barn deltar i aktiviteter med evolution i fokus. Genom att förstå vad som påverkar barns meningsskapande, kan lärare och forskare hitta meningsfulla och fruktbara sätt att undervisa naturvetenskap i förskoleklass och grundskolans tidigare år. Det finns inte ett ultimat sätt att undervisa kring evolution. Men, genom att förstå hur olika material, interaktion och förkunskaper påverkar meningsskapande, kan lärare och forskare stimulera barns meningsskapande.

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Appendices

Appendix 1: Information for principal, data collection 1

Hej!

Jag heter Johanna Frejd och arbetar som doktorand i naturvetenskapernas didaktik vid Linköpings universitet. Jag är examinerad förskollärare och lärare mot grundskolans tidigare år. Innan jag påbörjade min forskarutbildning arbetade jag inom förskola och skola.

Inom ramen för min forskarutbildning kommer jag att göra studier som ligger till grund för min doktorsavhandling. I min första studie kommer jag att undersöka hur barn i förskoleklass i mindre grupper (fyra barn i varje grupp) samtalar kring artbildning med hjälp av en världskarta och små leksaksdjur. Syftet med detta är dels att se hur de förklarar artbildning, dels att undersöka hur interaktionen mellan barnen påverkar förklaringarna. Inför samtalen kommer jag att be barnen rita och berätta hur de tänker individuellt. Beräknad tidsåtgång för insamlandet av material är 30 minuter/gruppsamtal och 15 minuter/enskilt samtal. Både individuella intervjuer och gruppsamtalen kommer att videofilmas. För att barnen ska känna sig trygga med att samtala med mig kommer jag att delta i den ordinarie verksamheten under några dagar innan jag påbörjar mitt arbete.

De forskningsetiska regler som finns för samhällsvetenskaplig forskning kommer att följas. Det innebär bland annat att allt insamlat material endast kommer att användas i forskningssyfte och då behandlas under strikt konfidentiella former. I avhandlingen kommer alla namn fingeras/anonymiseras.

Att delta i denna studie är helt frivilligt och deltagandet kan när som helst avbrytas. Barn och vårdnadshavare informeras om studien och ges möjlighet att samtycka/avböja till att delta.

Om det finns frågor kommer jag gärna till skolan och berättar mer.
Med detta brev följer en blankett där du kan godkänna eller inte godkänna att verksamheten på XX-skola deltar i studien så som beskrivits

ovan genom att ringa in antingen JA eller NEJ och sedan skriva under med namnteckning.

Med vänliga hälsningar
Johanna Frejd
Tel: 011-363507 E-post: johanna.frejd@liu.se

För mer information går det också bra att kontakta mina handledare vid Linköpings universitet:
Docent Magnus Hultén, magnus.hulten@liu.se
Lektor Karin Stolpe, karin.stolpe@liu.se

Appendix 2: Information for principals, data collection 2

Hej!

Jag heter Johanna Frejd och arbetar som doktorand i naturvetenskapernas didaktik vid Linköpings universitet. Jag är examinerad förskollärare och lärare mot grundskolans tidigare år. Innan jag påbörjade min forskarutbildning arbetade jag inom förskola och skola.

Inom ramen för min forskarutbildning gör jag studier som ligger till grund för min doktorsavhandling. I min första studie undersökte jag hur barn i förskoleklass i mindre grupper samtalade kring evolution och artbildning med hjälp av material (bland annat en världskarta och små leksaksdjur). Syftet med detta var att se hur barn skapar mening i interaktion med andra och med material. Nu vill jag ta den här studien ett steg längre och undersöka hur barns meningsskapande ser ut när sagor används som resurs för att introducera evolution. För att undersöka detta vill jag arbeta med barn i grupper om fyra i en slags intervention där jag använder material för att skapa en berättelse. I nästa steg vill jag låta barnen diskutera sina idéer kring hur det kommer sig att djur utvecklas olika med varandra. Beräknad tidsåtgång för insamlandet av material är 60 minuter/grupp. Både sagoberättandet och gruppsamtalen kommer att videofilmas. För att barnen ska känna sig trygga med att arbeta med mig vill jag delta i den ordinarie verksamheten under några dagar innan jag påbörjar mitt arbete.

Verksamma pedagoger behöver inte arbeta med det material som jag har med mig, utan jag håller själv i både sagoberättande och efterföljande diskussioner.

De forskningsetiska regler som finns för samhällsvetenskaplig forskning kommer att följas. Det innebär bland annat att allt insamlat material endast kommer att användas i forskningssyfte och då behandlas under strikt konfidentiella former. I avhandlingen kommer alla namn fingeras/anonymiseras.

Att delta i denna studie är helt frivilligt och deltagandet kan när som helst avbrytas. Barn och vårdnadshavare informeras om studien och ges möjlighet att samtycka/avböja till att delta.
Om det finns frågor kommer jag gärna till skolan och berättar mer.

Med vänliga hälsningar

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Appendix 3: Information for caregivers, data collection 1

Till vårdnadshavare för elev vid XXskolan
Jag heter Johanna Frejd och arbetar som doktorand i naturvetenskaper-nas didaktik vid Linköpings universitet. Jag är förskollärare och lärare mot grundskolans tidigare år och har tidigare arbetat inom förskola och skola.

Jag avser att genomföra en studie i ditt barns klass kring hur barn disku-terar artbildning. Till sin hjälp kommer de att ha kartor, bilder på djur och leksaksdjur. Studiens syfte är dels att se hur elever förklarar artbild-ning innan de blivit undervisade om det, dels att undersöka hur samtalet mellan barnen påverkar förklaringarna. Inför samtalen kommer jag att intervjua varje barn enskilt så att de får berätta för mig hur de tänker. Både de enskilda samtalen och gruppsamtalen kommer att videofilmas. För att barnen ska känna sig trygga med att samtala med mig kommer jag att delta i den ordinarie verksamheten under några dagar innan jag påbörjar mitt arbete.

De forskningsetiska regler som finns för samhällsvetenskaplig forskning kommer att följas. Det innebär bland annat att allt insamlat material endast kommer att användas i forskningssyfte och då behandlas under strikt konfidentiella former. I avhandlingen kommer alla elevers namn att fingeras/anonymiseras.

Att delta i denna studie är helt frivilligt och deltagandet kan när som helst avbrytas. Prata gärna med ditt barn hemma om att jag gör en studie. Med detta brev följer en blankett där du kan godkänna eller inte godkänna att ditt barn deltar i studien så som beskrivits ovan genom att ringa in an-tingen JA eller NEJ och sedan skriva under med namnteckning. **Lämna blanketten till ditt barns lärare senast 2015-03-16.**

Om det finns frågor får du gärna kontakta mig så kan jag berätta mer.
Med vänliga hälsningar
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För mer information kan du också kontakta mina handledare vid Linköpings universitet
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Lektor Karin Stolpe, karin.stolpe@liu.se

Appendix 4: Information and consent form for caregivers, data collection 2

Till vårdnadshavare för elev vid XX-skolan
Jag heter Johanna Frejd och arbetar som dokto-
rand i naturvetenskapernas didaktik vid Linkö-
pings universitet. Jag är förskollärare och lärare
mot grundskolans tidigare år och har tidigare ar-
betat inom förskola och skola.

Min forskning handlar om hur vi kan förstå och stötta barns lärande i
naturvetenskap. I en kommande studie avser jag att undersöka hur be-
rättelser och material kan stödja barns meningsskapande om hur arter
utvecklar olika egenskaper. Studien utgör en del av min avhandling.
Datainsamlingen kommer gå till så här: Först kommer ditt lyssna till en
saga om hur ett fiktivt djur utvecklats. Efter detta kommer barnen skapa
ett ler-djur som skulle kunna bo i en helt annan typ av miljö. I det andra
momentet kommer barnen få frågor kring hur de resonerar. Båda mo-
menten kommer göras i grupp och videofilmas. För att barnen ska känna
sig trygga med att samtala med mig kommer jag att delta i den ordinarie
verksamheten under några dagar innan jag påbörjar mitt arbete.

De forskningsetiska regler som finns för samhällsvetenskaplig forskning
kommer att följas. Det innebär bland annat att allt insamlat material
endast kommer användas i forskningssyfte och då behandlas under strikt
konfidentiella former. I avhandlingen och andra presentationer av resul-
tatet kommer alla elevers namn att fingeras/anonymiseras och eventu-
ella bilder från filmerna kommer manipuleras så att det inte går att
känna igen personerna.

Det är helt frivilligt för ditt barn att delta i denna studie och deltagandet
kan när som helst avbrytas. Jag frågar alltid barnet om hen vill delta och
tycker att det är okej att bli filmad. Prata gärna med ditt barn hemma om
att jag gör en studie. Med detta brev följer en blankett där du som vård-
nadshavare kan godkänna eller inte godkänna att ditt får delta i studien
så som beskrivits ovan genom att ringa in antingen JA eller NEJ och se-
dan skriva under med namnteckning. **Lämna blanketten till ditt
barns lärare senast 2017-12-11.**

Om du har frågor får du gärna kontakta mig så kan jag berätta mer.
Med vänliga hälsningar
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Karin Stolpe, karin.stolpe@liu.se

Konrad Schönborn, konrad.schonborn@liu.se

Samtyckesblankett vårdnadshavare

Jag har tagit del av information om Johanna Frejds studie. Vid gemensam vårdnad behöver endast en vårdnadshavare skriva under, men det förutsätter att båda vårdnadshavarna är överens om beslutet.

JA
Jag godkänner att mitt barn deltar i Johanna Frejds studie.

NEJ
Jag godkänner inte att mitt barn deltar i Johanna Frejds studie.

Datum..............................

Vårdnadshavare:

....
Namnteckning

....
Namnförtydligande

Barnets namn:

....

Samtyckesblankett vårdnadshavare

Jag har tagit del av information om Johanna Frejds studie.

JA
Jag godkänner att mitt barn deltar i Johanna Frejds studie.

NEJ
Jag godkänner inte att mitt barn deltar i Johanna Frejds studie.

Datum…………………………

Vårdnadshavare:

………………………………………………………
Namnteckning

………………………………………………………
Namnförtydligande

Barnets namn:

………………………………………………………

Appendix 6: Information and consent form for teachers, data collection 2

Till Pedagog vid XX-skolan

Jag heter Johanna Frejd och arbetar som doktorand i naturvetenskapernas didaktik vid Linköpings universitet. Nu planerar jag för att genomföra en studie som ska utgöra en del av min avhandling. Avhandlingens övergripande syfte är att undersöka hur vi kan förstå och stötta barns tidiga meningsskapande i naturvetenskap.

Vecka 50 2017 planerar jag att vara i din klass för att undersöka hur berättelser och material kan stödja barns meningsskapande om hur arter utvecklar olika egenskaper. Datainsamlingen kommer gå till så här: Först kommer du att läsa en saga för barnen och efter det kommer barnen fortsätta berättelsen och skapa ett djur som skulle kunna överleva i en specifik miljö. I det andra momentet kommer jag vara med och leda aktiviteten. Båda momenten kommer göras i grupp och videofilmas. Jag önskar även filma dig som läser berättelsen för att kunna fånga interaktionen som sker mellan dig, barnen och boken/berättelsen.

För att alla ska känna sig trygga med att samtala med mig kommer jag att delta i den ordinarie verksamheten under några dagar innan jag påbörjar mitt arbete.

I svensk forskning finns forskningsetiska regler som ska följas. Det innebär bland annat att allt insamlat material endast kommer användas i forskningssyfte och då behandlas under strikt konfidentiella former. I avhandlingen och vid andra presentationer av resultatet kommer alla deltagares namn att fingeras/anonymiseras och eventuella bilder från filmerna att manipuleras så att det inte går att känna igen personerna.

Att delta i denna studie är helt frivilligt och deltagandet kan när som helst avbrytas. Med detta brev följer en blankett där du kan godkänna eller inte godkänna att du deltar i studien på det sätt som beskrivits ovan. Du kan alltid kontakta mig om du vill ha mer information.

Med vänliga hälsningar
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Karin Stolpe, karin.stolpe@liu.se
Konrad Schönborn, konrad.schonborn@liu.se

Samtyckesblankett pedagoger

Jag har tagit del av information om Johanna Frejds studie.

JA
Jag godkänner mitt deltagande i Johanna Frejds studie.

NEJ
Jag godkänner inte mitt deltagande i Johanna Frejds studie.

Datum……………………………

……………………………………………………………
Namnteckning

……………………………………………………………
Namnförtydligande

Papers

The papers associated with this thesis have been removed for copyright reasons. For more details about these see:

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