Chapter 5
Knowledge Construction in Early Childhood Science Education

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Abstract In this chapter we discuss forms of knowledge construction and consider these in relation to early childhood science education literature. We examine different regions of the world to see how research in science education has developed and what it has allowed us to better understand about the young learner. We consider the forms of logic drawn upon by scholars in the Australasia and South Pacific region, in the European and Nordic region, and the US. In order to understand the contributions these scholars have made for early childhood science education, we explore the forms of knowledge within the context of the child development paradigms that have underpinned science education. Our analysis of the literature draws upon a critique the following three paradigms: *the individualistic paradigm*, the *social interactionist paradigm*, and a *cultural-historical paradigm.* In this chapter empirical examples are presented in their original form from the country from which they were generated. This locates the research and theoretical concepts, but it also gives a more genuine international focus when conceptualsing science learning.

Keywords Individualistic paradigm • Social interactionist paradigm • Cultural-historical paradigm • Australasia and South Pacific region • European region • Nordic region • United States

5.1 Introduction

Carter (2007) in reviewing the vast body of empirical literature into science education makes the claim that "Despite years of formal science education, students' scientific misconceptions are common, and their lack of motivation and feelings of alienation show in the decreasing numbers opting to take science beyond the compulsory years" (p. 3). Although this is probably specific to the Western literature, and to Western constructions of science, her work does provide an interesting analysis as to what has gone wrong. She states that the "research argues the need for science education to go beyond imparting scientific conceptual knowledge and skills and advocates critical participation in a world dominated by science" that is "conceptualized by sociocultural and political interests" (p. 7). Here she suggests that science has become "mythologized" into a "scientific practice recapitulated as

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received knowledge in school science curricula" (p. 7) where an objective and reductionist view of science is conceptualized as the *scientific method*.

Much of the literature into school science suggests that these problems can be overcome if science is more authentic for children in schools, where better learning will result when they are exposed to the "messiness of scientific knowledge construction" (Carter, 2007, p. 7). Science has become increasingly discredited as arguments about sustainability have shown, due in part to the widespread belief that science will reveal a single truth real. When multiple expert views are publicised in the media, general confusion in the community results. Carter claims that in the context of an increasingly global community, where diverse students, knowledges and practices reign, and where a fragile ecology has becoming increasingly evident, that "shared meanings have receded, and have been replaced by uncertainty and insecurity" (p. 2). Yet in this context science education has predominantly been framed as an empirical approach to knowledge construction, where it has been the tradition for "science education to be "derived from highly abstract and fragmented statements of Western canonical knowledge" (p. 2). This approach to science education foregrounds a particular form of logic, resulting in empirical knowledge that has positioned us as now being ill-equipped and unable to move forward into the twenty-first century (Carter, 2007). What this analysis highlights is the differing forms of knowledge construction possible in science.

In this chapter we discuss forms of knowledge construction and consider these in relation to early childhood science education literature. We examine different regions of the world to see how research in science education has developed and what it has allowed us to better understand about the young learner. We will consider the forms of logic drawn upon by scholars in the Australasia and South Pacific region, in the European and Nordic region, and the US. In order to understand the contributions these scholars have made to early childhood science education, we explore the forms of knowledge within the context of the child development paradigms that have underpinned science education. Our analysis of the literature draws upon a critique the following three paradigms:

1. *The individualistic paradigm*
2. *Social interactionist paradigm*
3. *Cultural-historical paradigm*

5.2 Three Paradigms for Understanding Children's Development in Science

As has been discussed in Part I of this book, a cultural-historical reading of science education in early childhood settings brings together as inseparable the individual, the environment and the social dimensions or interactions between individuals. Understanding how the child develops in this dialectical relation has been a hotly contested area within the field of early childhood education generally, due to longstanding assumptions about child development. Rather than reproduce the critiques found in the literature on approaches to child development, such as, developmentally appropriate practice, we will explore three general paradigms that underpin different forms of child development. We do this so we can better understand how knowledge construction in science learning has been framed, and why a cultural-historical reading of science education is productive for early childhood science education. But this is also important because in the broader field of early childhood education, researchers and practitioners have always engaged in critiques of theory about children's development, and historically both constructivist theories (see Chap. 1) and developmentally appropriate practices, have been left wanting.

5.2.1 The Individualistic Paradigm

Underpinning science education and early childhood education specifically has been epistemological individualism. That is, "a commitment to the notion that the mind is the outcome of processes set in motion by the individual organism" (Scribner, 1997, p. 281). The focus in early childhood education has traditionally been on finding out what the individual thinks, documenting each child's development through observations of what an individual says and does, and placing these records into individual portfolios (Fleer, 2010). This represents an *individual-world* model, where each element – individual – world – function as a natural isolated system. The world acts upon the child, and the child internalizes these actions. Scribner (1997) suggests that internalized actions "are gradually coordinated into increasingly powerful structures of thought which can be described by logical models" (p. 282). Piaget's (1972) original work demonstrated this form of logic through the example of a child placing pebbles on the ground, counting in one direction and then counting from the other direction. Wondering about the results (i.e., same number counted in both directions), the child re-arranges the pebbles and puts them into a circle, with still the same result. A level of abstraction occurs when the child is able to *deduce* from the evidence she has gathered (three different ways of counting the same pebbles) a common result, giving rise to an understanding that the sum of the elements is independent of the order of the pebbles. This elementary form of deduction laid the foundation for the child's mathematical reasoning. But this explanation is also the basis of scientific deduction. In an individualistic paradigm the social dimension is factored in, but only as retarding or accelerating the natural development of the child's deductive reasoning. The evidence used to build this theoretical approach to child development has been extensively critiqued (see Chap. 1) and is generally well known (e.g., Donaldson, 1978; Hundeide, 1985). *As will be seen when we review the literature further in this chapter, it is surprising to see that many early childhood education researchers still organise their research with an individualistic perspective in mind.*

5.2.2 Social Interactionist Paradigm

George Herbert Mead sought to interrupt the world-mind dichotomy with a sociogenetic account of how learning developed. In this logic, Mead conceptualized the development of thought as the individual *and* the world as inseparable. In this logic the development of thought was considered as occurring through the *coordination among* individuals in social interaction. For example the child who is counting pebbles is no longer conceptualized as being on her own, but rather as learning with others. The child together with other children, discuss where to start counting, from which end, or where to begin counting in the circle. If they all start counting in different places will the result be different? Scribner (1997), in citing the original experiments of Doise and Mugny (1984), states that a form of sociocognitive conflict results when different points of view are given and the children work out how to resolve the differences. *As was shown in Chap. 1, this worldview underpins the movement to socioscientific view of teaching science, where argumentation as an approach underpins secondary schools science in many countries around the world.* This was a major paradigm shift at the time because it established a new perspective in psychology and in education for a social account of cognitive development. Scribner (1997) sums up a social interactionist perspective as "cognitive development can be understood as a spiral of causality in which various cognitive preconditions in the child, which are themselves based on previous social interactions, allow the child to participate in more complex social interactions, ensuring the elaboration of more complex cognitive instructions, and so on." (pp. 283–284).

5.2.3 Cultural-Historical Paradigm

Scribner (1997) was early to recognise that social interactionist perspectives, whilst moving forward in terms of embedding children's thinking in interactions among others, that this perspective "cut off cognition from objects and actions in the world of things" (p. 283). She argued that "social interaction begats cognition which begats social interaction in ever-increasing complexity" (p. 284). This she suggested is still a bifurcated picture of child development, and both paradigms (individualism and social interactionist paradigms) "entirely ignore the larger system of social relationships and practices which constitute society and culture, and make individual transactions possible and meaningful" (p. 284). In science education, a cultural-historical paradigm offers a very different reading of how scientific learning progresses. A cultural-historical account of learning suggests that children are not simply engaging in material things, learning about their properties, but rather they are engaged in social modes of interaction where they are learning codes of behaviour and societal and family rules and activities. These are family, country and culture specific. Learning to use a spoon, your right hand, or chop sticks, to eat is not just about managing the tool, but it is also the social conventions which inform how that tool should be used within a given family, community and culture. Tool and symbol use are not learned independently of society, but rather they are part of a socially mediated process. The object or the action has no meaning without someone giving it meaning. Teachers introduce scientific tools and actions as a form of mediated action. A thermometer (object) or the scientific method (action) or a particular scientific word (sign), are all given meaning through others in socially meaningful situations in our community, family or classroom. The child's engagement in the world with others gives meaning to actions and object relative to the societal values, goals and needs. In this activity setting the child has agency and contributes to shaping how, when and where this socially produced mediation is actioned (Fleer, 2010; Hedegaard and Fleer, 2013). This is a unitary process that represents "an integrated view of human ontogeny capable of assimilating empirical findings and raising new questions" (Scribner, 1997, p. 287). Yet a close look at the literature shows that this latter view of development and learning in science has not been extensively used in early childhood science education.

We now turn to a detailed examination of the research literature on early childhood science education in order to determine how research has been framed. We draw upon the three paradigms of understanding children's development in science to analyse this literature. What do we know about the research in early childhood science education in regions such as Australasia and the Nordic region? What form of cultural knowledge has been created that we call early childhood science education? What forms of knowledge are privileged in these studies? In this chapter we seek to examine the research evidence that underpins early childhood science education across a range of countries. Specifically we review all those studies which focus on the prior to school settings, although at times we also examine science in the early years of school. We then move forward to discuss the specific nature of knowledge construction from the perspective of a more globally and culturally responsive approach for understanding early childhood children's thinking and learning in science education. The point of this chapter is to examine the forms and nature of knowledge in early childhood science education and to consider how this knowledge is constructed and privileged through the design and presentation of our research.

5.3 Australasian and South Pacific Contexts

In looking closely at what had been published about early childhood science education from 1972 onwards, we note that there are only a splattering of studies from this time period until the 1990s. Most of these fall with an individualistic paradigm where constructivism has been the dominant theory informing research. Generally, there are relatively few studies of early childhood science education in the Australasian and South Pacific region in the prior to school settings, and almost none outside of Australia and New Zealand published in English written journals.

Science education in the early childhood period in Australasia did not appear in the literature in any significant way until the beginning of the 1990s (Fleer, 2001). Even with the extensive research following constructivist approaches to science in New Zealand (e.g., Osborne & Freyberg, 1985), this work did not include the prior to school period. In 1990 Hardy and Bearlin (1990) included in their research early childhood inservice teachers, where they collectively created a gender-sensitive program for teaching science, specifically problematising the dominant empirical and traditional view of knowledge creation. How some of these teachers taught science in their preschools became the focus of research by Fleer (1990, 1991) and Fleer and Beasley (1991), but with a specific focus on children's conceptions in science in relation to how the teachers taught. The latter, although grounded in the language of alternative conceptions, drew upon cultural-historical theory to conceptualise the study and findings. These studies focused mostly on physics topics, an area that has been suggested to be outside of what most early childhood teachers were likely to teach (Fensham, 1991). In contrast Venville (2004) concentrated on topics more likely to be taught to young children, such as living things. Here the focus was on conceptual change, but from an ontological and social perspective. A social interactionist paradigm strongly influenced by cultural-historical theory begun to emerge in the science education literature. In line with the international literature at the time where alternative views held by children were considered as problematic, Venville studied conceptual change from both an ontological and a social constructivist perspective, drawing upon Vygotsky's theory of development. Venville found a number of patterns of learning relevant to conceptual change including, persistence of a nonscientific framework guiding thinking, a theoretical framework in transition, and for some, a successful radical change to a scientific framework.

In attempting to work outside of the dominant constructivist and individualistic frameworks guiding early childhood science education research, Fleer, Sukroo, and Faucett (1994, 1995) investigated Indigenous children's understandings in science, using role play and traditional stories to illicit their understandings, noting that these approaches did not specifically allow for gaining insights into children's cultural constructions of knowledge, even with Indigenous researchers guiding the study and undertaking the interviews. These studies highlighted the culturally specific nature of framing science education research. Environmental frameworks for learning science have also featured, but mostly these focus on thinking about looking after the environment, with only one specifically examining how scientific concepts aid this process (see Cutter-MacKenzie & Edwards, 2006; Edwards & Cutter-Mackenzie, 2011).

A slow movement towards a cultural-historical paradigm was emerging, but within a context of not a great deal of research into early childhood science education. For instance, in 1991 a themed issue on science and technology education was published in the *Australian Journal of Early Childhood*, representing not only the first issue on this topic, but with the exception of one paper published early in the history of the journal, no other paper on science had been published until that time. However, early childhood science education was the focus of a themed issue of *Research in Science Education* in 2003. This issue predominantly featured research from Australasian region, with Fleer and Robbins (2003a, 2003b) highlighting the shortcomings of a constructivist inspired research for investigating very young children's thinking. In their cultural-historically framed paper they argued that traditional approaches to investigating young children's thinking in science in Australia have been fraught because they privilege knowledge generation for those who use a 'question and answer' discourse. In that same issue Tytler and Peterson (2003) also discuss the limitations of previous research designs for gathering information on young children's thinking. They noted in their Australian longitudinal research that children's thinking, particularly their reasoning, is well in advance of curriculum expectations. This was also noted by Fleer (1991) in a cultural-historical study of 4-year-old children's learning of electricity, where the teacher used scaffolding techniques to support science learning. She found that "children are most receptive to learning experience which help them to understand everyday phenomena no matter how difficult the concepts are perceived to be by the adult world" (p. 102).

Robbins (2003, 2009) in drawing upon cultural-historical theory has also investigated young children's thinking in science, specifically looking at their understandings of night and day. In examining other studies in this area, where knowledge construction and interviewing approaches focused primarily upon gathering empirical knowledge following traditional approaches, less was learned about young children's thinking than when a cultural-historical approach was adopted where relational knowledge was drawn out over extended time. As Robbins (2003) states "Traditional approaches to discovering young children's ideas in science tend to isolate the individual and decontextualise thinking in order to uncover certain accepted scientific views. However, research from a sociocultural perspective recognises that cognition is a collaborative process" (p. 5). What was emerging within the very small pool of research into early childhood science education, was a concern for the social and cultural context of science, rather than a simple focus on concept formation within an individualistic paradigm for designing studies. Concerns were expressed by Segal and Cosgrove (1993) who found that more could be learned about young children's understandings of light if a broader context was used for data gathering. In drawing upon learning model of cooperative learning, informal enquiry and familiar contexts, they examined not just individual understandings of light, but sought to examine the social construction of knowledge about light and shadows. They state "Our observations of children behaving casually and even seemingly off task in groups, particularly in outside settings, belie the serious conversations occurring there" (p. 283).

The individualistic paradigm with its focus on what a child knows in science, was elaborated to include the study of the educators who worked with young children. For instance, early childhood teachers' knowledge of science was a focus for Garbett (2003), who was highly critical, stating that there is a real lack of scientific knowledge amongst early childhood teachers in New Zealand. Her study, which included teachers with cultural backgrounds of Maori, Pakeha and South Pacific Islanders, suggested that these student teachers were not aware of their lack of content knowledge. She suggested that science content knowledge is even more important for early childhood teachers to learn because the open-ended pedagogical approaches adopted require greater knowledge of conceptual understandings of science if science is to be successfully taught in those contexts. Fensham (1991) has also written extensively on the lack of content knowledge of teachers during a review of teacher education in science, specifically mentioning early childhood teachers in Australia. Fleer (2009a) in expanding on this work, but in taking cultural-historical perspective, claimed that it is not just teacher knowledge of science that is the central problem, but rather the pedagogical approach and beliefs about how children learn and develop. For instance in her case study of 4-year-old children and their teachers, she noted that the lead teacher wanted a free flow program where learning of science was to occur through the provision of materials, without direct teacher introduction or conceptual framing, and where the teacher suggested the children learn in a roundabout way. In another case study by Fleer (2009b) of 4-year-old children and their teachers, she noted that when the teachers' beliefs about teaching and learning followed a cultural-historical approach where theoretical knowledge (see Chap. 6) was being developed, that the children's learning in science was much more advanced, despite the original lack of science knowledge of the teachers about the topic being explored. That is, when the teacher actively focused on the concepts in the play-based program, both teachers and children learned more science, than if they simply organised the environment with materials (see Chap. 7). In taking a broader view of teacher knowledge, Alexander and Russo (2010) in a project known as Operation Magpie, found that teachers and children became engaged in science through investigating magpies and other birds in their environment, but their conceptual knowledge in science did not significantly improve. The social context began to feature more strongly in the study designs over time. For example, in a study that examined questions and opportunities for children's learning in science at home, as well as how the science learning in a child care centre influenced what children did at home, Fleer (1996) found that children aged 2–5 year children asked significantly more scientific questions at home than in their child care centre, despite the teaching program following an interactive approach to teaching science. The study noted that children became more curious about everyday events that could be explained scientifically, and children used the scientific language introduced in the centre in the home as a direct result of the science learning occurring in the day care centre across the topics of materials, change of state of matter, evaporation and condensation, dissolving and chemical change). These studies point out that more authentic research in early childhood education becomes possible when the research net broadens and goes beyond simply finding out teacher thinking in science, such as conceptions in biology (Edwards & Loveridge, 2011).

What we begin to see is a deeper understanding of the range of ways that the pedagogy influences thinking in early childhood science. For instance, Blake and Howitt (2012) in investigating science learning opportunities in three early learning centres noted three different contexts for learning science, as shown: "*Satisfying curiosity*, *Guided play* and *Lost opportunities* where teachers' responses about the importance of science teaching and learning varied and did not appear to match the investigations" in the two centres where science learning was happening.

Interestingly the centre where guided play was occurring this "enabled the children to advance their scientific knowledge through hands-on engagement" while the centre where children explored freely they tended to lose the "initial possibilities as children lost interest and no follow-up activities to embed the learning" were provided. In the more liberal approach to learning where the children were encouraged to satisfy their curiosity in an unstructured environment and freely use resources to "advance skills according to their own agenda . . . while being encouraged and supported by caregivers" allowed for a lot of science learning to occur (p. 297).

An individualistic paradigm has emerged in both the conceptual change literature and early childhood teacher views of child development where studies of early childhood teacher professional learning have been undertaken (Watters, Diezmann, Grieshaber, & Davis, 2001, p. 1). The results show that teachers drew upon their knowledge and beliefs of a child centred view of learning and applied this to science learning. These studies show that teachers' personal knowledge of science had increased; they gained strategies specific for teaching science; and investigations rather than experiments were found to be more useful. Importantly teachers commented on the significance of having an inservice program designed specifically for play-based settings, where teachers' confidence and competence to teach science was clearly taken into account. The study design of Watters et al. (2001) goes beyond simply documenting what teachers know in science, and reveals both personal and social factors as key to better understanding early childhood teacher knowledge of science. The specific learning needs of early childhood teachers were also considered by Howitt (2011) in her sociocultural design and piloting of early childhood science resources. An Interactive resource known as *Planting the seeds of science* was developed specifically to encourage early childhood teachers to teach science. The program was piloted across a range of early childhood centres, and the finding show that teachers were immediately engaged with the resource, stating that it filled a huge gap because the resource was designed specifically for early childhood teachers, as apposed to teachers having to adapt materials planned for non-play-based settings in primary schools (Howitt, 2011). Follow up research by Howitt, Upson, and Lewis (2011) has shown that the unit of work on forensic science in the resource represents a highly contextualized and interesting approach to teaching science in early childhood, where "providing opportunities for them to participate in scientific inquiry processes (generating questions and predictions, observing and recording data, using equipment, using observations as evidence, and representing and communicating findings) and knowledge building" (p. 54) resulted. Similarly Morris, Merritt, Fairclough, Birrell, and Howitt (2007) examined the usefulness of concept cartoons as a resource for teachers finding that them to be highly stimulating and valuable for early childhood teaching. These studies add greatly to our understandings of the special learning needs of early childhood teachers, and they recognize the unique pedagogical contexts in which these teachers work. Rather than taking a deficit view of early childhood teachers' subject content knowledge of science, these studies look more broadly at the personal and contextual factors associated with learning and teaching.

Personal and social factors have also been recognized by Hardy and Bearlin (1990) who in drawing upon an interactive approach to teaching science developed professional learning approach for both preservice and inservice teachers known as the Primary and Early Childhood Science and Technology Education Project (PECSTEP). PECSTEP was designed to improve teaching and leaning in science for both early childhood and primary teachers. The outcomes of their year long study showed that teacher interest in science and the teaching of science improved, that teacher conceptions of science and technology changed from depersonalized and decontextualised body of knowledge to becoming seen as a human endeavour, broader range of teaching strategies were employed, implicit valuing of women's experiences related to science, and changes in the personal power of the participants. Hardy and Bearlin state that "We believe that for lasting attitude change to occur there must be a change of consciousness on the part of the teacher which involves a changed understanding of the nature of scientific knowledge" (p. 150). This research recognised gender as an important factor in science teaching. Few studies have examined this area since.

In 2012 Howitt et al., in drawing upon the literature which suggested the need for specifically designed courses for early childhood preservice teacher to improve their confidence and competence to teach science, designed a course with an engineering focus where both early childhood academics and engineering academics participated in the workshops. Five principles were featured in the workshops: "acknowledgement of the place of young children as natural scientists, active involvement of children in their own learning through play and guided enquiry, recognition of the place of a sociocultural context within children's learning, emphasis on an integrated approach to children's learning experiences and the use of a variety of methods for children to demonstrate their understanding and learning" (p. 162). Pre-and post-test results of teachers' confidence to teach science improved, with a range of reasons being identified for this change. Of these teachers 82 % believed that being shown to teach science had resulted in their feeling confident to teach science, 58 % of this group also stated that knowing about resources and activities for teaching science improved their confidence, and 10 % stated that the methods of teaching science had made a difference to their confidence. In terms of preservice teachers knowledge of science concepts, survey results show that not only did they feel more knowledgeable about engineering principles, but they also better understood concepts in astronomy, energy, chemistry, and the principles of forensic science. Howitt, et al. (2012) found that "the pre-service teachers did not consider science content knowledge to be the most important reason for their increased confidence" (p. 170) where science pedagogy and the science activities were found to be more important than the science content knowledge for improving confidence to teach science. This finding is supportive of earlier research, and again points to the significance of personal and social pedagogical context of knowledge construction in the teaching of science in early childhood.

In Korea we see other priorities in early childhood science emerge. Joung (2008) in drawing upon activity theory, examined how a 5-year-old child used abductive inference in science education (logical inference to give an explanation to an unbelievable situation), where typically (intuitive experienced-based) and perceived-situations (context dependent) were considered in everyday situations at home. Inagaki and Hatano (2006) examine how 5 year old Japanese children posses a theory-like knowledge system they have termed Naïve biology, allowing them to predict and give causal reasons for biological phenomena. No other studies written in English could be found for Korea or Japan. Similarly, only one study from China on early childhood science could be found for the prior to school period (even with a search of the Chinese written literature). Liu Hui (2011) discusses not just the need for kindergarten children to learn science, but also that children should be guided "to understand the moral mission of science and promote their aesthetic experiences about science" in China (p. 66). Rather than a focus on only conceptual knowledge, Liu Hui suggests that science knowledge must be learned within a moral framework, and the aesthetic dimensions should also be foregrounded. This orientation is missing from the Australian and New Zealand studies, which make up the bulk of the literature found across the Asia pacific region.

In the studies reviewed for this region, we note that knowledge construction has been conceptualized by many following a cultural-historical tradition and methods for gathering data were noted to be broader than traditional approaches in science education research during that period, with some actively problematising the nature of Western and male constructions of science. Insights from China show that more attention should be paid to the moral and aesthetic dimensions of science, something that is absent from all of the literature reviewed. Mostly the studies reviewed for the region have tended to focus on either what children thought about specific science topics, or how confident their teachers were to teach science, and how they may be supported through both preservice and inservice programs or specifically designed resources. What we do learn from the review of those studies available is that Indigenous knowledges were rarely examined. Of significance is that most researchers made references to empirical science content knowledge, but problematised the nature of this knowledge construction for early childhood education or used cultural-historical theory to conceptualise their work, where the development of theoretical knowledge is foregrounded. We now turn to the Nordic context in order to explore the research into science learning of early childhood children in that region so that we can see what forms of knowledge construction exist. We specifically examine how knowledge construction is shaped by the paradigms in which the studies are framed and undertaken.

5.4 Nordic Research on Early Childhood Science Education: A Cultural-Historical Paradigm

In this section we will review research studies on children's science learning from the Nordic countries, that is, Denmark, Finland, Iceland, Norway, and Sweden. In the Nordic countries, children tend to spend a great deal of their time at their preschool outside (see Einarsdóttir & Wagner, 2006, for texts on early childhood education in the Nordic countries; also Moser & Martinsen, 2010). It is common to make excursions to the forest or play outside even in the wintertime. Hence, there are ample opportunities for preschool teachers and children to explore and converse about nature and natural processes. Still, there is little research on young children's science learning. There are very few studies of direct relevance to the present volume. In this brief review, we will mention studies we have found but will only discuss, in some length, a limited number of studies, which are of particular interest to the themes of the present volume. Other studies (such as Thulin, 2010; Thulin & Pramling, 2009; Pramling, 2010) will be referred to more extensively in the following chapters, in relation to our discussion.

The majority of studies on young children's science learning during the last years are based on a theoretical frame that is, more or less, in line with the theory of the present book, cultural-historical theory. However, in the Nordic countries, when studying children's science learning, this perspective is commonly referred to as a socio-cultural perspective. Perspectives that are somewhat adjacent to this perspective (see e.g., Greeno, Collins, & Resnick, 1996, for an overview), such as a pragmatist perspective (e.g., Jakobson & Wickman, 2007, 2008; Klaar & Öhman, 2012) and the multimodal perspective of Gunther Kress and his colleagues (Kress, Jewitt, Ogborn, & Tsatsarelis, 2001) are also used (e.g., Elm, 2008; Elm Fristorp, 2012), if to a lesser extent. One reason for the dominance of socio-culturally informed studies may be the widely read and influential book, *Lärande i praktiken: Ett sociokulturellt perspektiv* [English: Learning in Practice: A Sociocultural Perspective] as published in Swedish by Roger Säljö in 2000. The book, which can also be read by people in Norway and Denmark as well as by many people on Iceland and in Finland has subsequently also been translated to several Nordic languages. The book was pivotal in introducing what for many was then a new perspective into educational research in the Nordic countries, including research on science education. The perspective that has dominated science education for a long time with older children and adolescents (STCSE database), that is, cognitive and/or developmental psychology is not prominent in the research on younger children's science learning in the Nordic countries.

5.4.1 Communicative, Contextual and Institutional Embeddedness

Sträng and Åberg-Bengtsson (2009) studied a group of 5-year-old children together with their teacher visiting a science centre. There they attended an exhibition called 'Way of the water', consisting of a large-scale model that you walk through, that follows the flow of water "from the mountain range in the uplands of northern Sweden down to the Baltic Sea through a number of environmental and cultural settings abstracted from the Swedish landscape" (p. 14). The children were followed attending the exhibition during the guidance of a guide from the center and later back at their preschool at circle-time when they discussed with their teacher what they had experienced at the centre. The researchers pose three questions: First, what content was focused on; second, what communicative strategies the guide and teacher, respectively, used when talking with the children about the exhibition; and third, the different ways that the interaction between the adults and the children were contextually framed.

The children participating in the study worked with their teacher for a prolonged time with the theme 'water' in various ways, for example visiting a brook nearby their preschool. During their visit to the science centre, they were accompanied by their teacher, a science centre guide and four parents. The parents and the teacher each wore an audio-recording device, recording talk between children and between the guide, teacher and children. The teacher also took photographs during their walk along the model. The researchers describe the model in the following way:

> The children entered the exhibition through a dark corridor, where the sound of thunder was heard, before climbing a staircase to the highest point of the model, where they met a Sámian teepee in front of a relief of a mountain with some (plastic) snow on the top. No water ran from this point of the model, but there was a brook painted on the relief. The sounds of rippling water as well as howling wolves and singing birds were heard. At the bottom of one flight of stairs, there was a pool with fish typically found in streams in the northern parts of Sweden. Still further down the 'Way of the water' was a beaver's lodge. In some places running water could be seen, while in others it could only be heard. (ibid., p. 19)

(The Sámi, whose teepee is referred to, are the indigenous people of northern Europe: Sweden, Norway, Finland, and parts of Russia.) After the visit to the science centre, as already mentioned, the teacher had a follow-up discussion with the children at circle-time a week later. Analysing these two learning situations (the guided tour at the science centre and the follow-up discussion at the preschool), Sträng and Åberg-Bengtsson found three different communicative patterns (i.e., ways of interacting) that they suggest are related to different contextual framings. These three patterns are illustrated and analysed in the article. But briefly described, the first pattern consists of "providing facts" and was used by the guide at the science centre; the second pattern identified, "directing attention by posing questions" were used by the teacher at the science centre; and the third pattern, "asking for accounts" was used by the teacher at circle-time. An example of the first pattern was that the guide told the children that "It's called a glacier. It is snow up there…" (p. 21). An example of the second pattern was the teacher asking the children "what's that?" and "what do you see?" (p. 22), while looking at a bird (a great crested grebe) in a pool. And an example of the third pattern was the teacher asking the children "is there anyone who remembers where the water went then?" (p. 25). In addition, while the teacher repeatedly asked the children about how the water ran, "there are no instances in our data where the children express the idea of the larger scale, coherent model. On the contrary, they talked only about individual parts of the exhibition" (p. 26). However, this may not be unexpected, since, as the researchers point out, "neither the guide nor the teacher tried to explain the model of the 'Way of the water' or scaffold the children's making of meaning of the flow of water in a more elaborated manner" (p. 28). There may be several reasons for this observation, as the researchers reason, including the model being taken for granted and therefore being left for the children themselves to 'discover'. The idea that the child, him or her self, should discover principles of nature and science (e.g., understand the model of the system) is common in discussions about children's science learning, as informed by an individualistic paradigm. However, to expect the children to discover this rather complex model (cf. the description of it above, clarifying that, for example, the water cannot be seen all the way), including understanding that "the pool with the great crested grebe represented the sea (or the Baltic Sea to be more precise)" (p. 27) is not realistic. The importance of teachers scaffolding children's sense-making through 'pointing out and linguistically informing their experiences' (Pramling & Pramling Samuelsson, 2011) is implied. This is a theme we will return to throughout the present book. Finally, Sträng and Åberg-Bengtsson (2009) conclude that children's development of 'model thinking', that is, in our alternative terms, managing representations of various kinds, is a field in much need of research into young children's science learning. This is a theme we will investigate in this book (see particularly, Chap. 10).

5.4.2 Tool-Mediated Inquiry into the Natural World

Ärlemalm-Hagsér, E (2008) conducted a study in order to provide developmental opportunities for and follow the development of children's understanding of insects. A cyclical design was used for the study. In brief, the approach meant to (i) try to investigate the children's experiences of insects at their preschool ground, (ii) create a learning situation where the children get to draw and talk about insects, and (iii), create a second learning situation, on the basis of the outcomes of the first one, in the forest where the children study and draw insects. The preschool teachers asked the children, "What insects do we have on the preschool ground? Draw some of these" (p. 72, our translation). Looking at the children's drawings and listening to them talking about these, it became clear that the children had a rich view of insects/"small creeping things", including ladybirds, beetles, earwigs, ants, bumblebees, shield bugs, spiders, woodlice and earthworms. They thus showed a wide awareness of different animals. The children also showed a good insight into the animals' anatomy, as evident in their drawings. Most children drew the animals from a birds-eye view. However, as seen in the list of animals depicted, the children did not differentiate between insects and other small animals. Hence, some of the challenges now facing the preschool teachers were how to support children in discerning insects as a particular species, and how to make children draw the animals (also) from a different perspective than the birds-eye view, in order to make visible other parts of the animal (on children's drawings in science education, see Chap. 10). The teachers were also self-critical about their own knowledge of the domain and how they could communicate more productively with the children, asking better questions, to further challenge the children's thinking.

Building upon what was found in the first step of the study, the teachers then tried to provide a new learning situation, introduced in the following way:

Teacher:	I know that you know many things here. Yes, a gread deal and I'm sure you're wondering many things, and today I was gonna ask you this: What are insects? What is that? Anybody knows?
Nils:	They're small creeps.
Maria:	They're this small (showing with her thumb and forefinger, appr. one millimeter). (p. 74, our translation)

According to the researcher, the children show the sizes of insects with their fingers and hands, resulting in a span from approximately 1 mm to 8 cm. The children are then asked to draw the insects.

Teacher:	We thought that we'd like to see when you draw your insects. How do the insects look?
Nils:	You mean super super super enhanced? (p. 75, our translation)

Nils' question about magnification is highly relevant to the task, but the teacher does not answer him. Continuing talking with each other and the teacher, the following takes place after a while:

Nils:	Guess what insect it is?
Teacher:	Someone who lives in a hill perhaps?
Maria:	An ant.
Nils:	Ants haven't two legs, but it has four legs.
Maria:	Spider.
Nils:	Spiders have eight legs.
Teacher:	Is it an insect that has two legs?
Nils:	No, four.
Teacher:	An insect that has four legs?
Nils:	One, one, one foot less than I'm years [old], when I'm five.
Maria:	Ladybird.
Nils:	Right (to Maria),'cause these here were dots (points at the lines on the upper part of the drawn body), those were the eyes and there were the legs (showing). Everything was super duper enhanced, if it should've been them, super duper enhanced. (p. 75, our translation)

In this excerpt, the issue of the number of legs of different animals is introduced. However, nothing more is made of this relevant feature at this time. Instead, other features important to an evolving understanding of insects and other animals come to the fore in the talk:

Teacher:	What is that on yours (directed to Nils, who has drawn a ladybird)?
Nils:	That's the eyes, there was a nose before but I erased it.
Teacher:	Why did you erase it then?
Nils:	'Cause ladybirds don't have any nose.
Teacher:	No, that's right, insects don't have noses.
Nils:	I haven't drawn any mouth.
Teacher:	No, do they have any mouths then?
Nils:	I don't think so.
Teacher:	You don't think so. How can they survive?

Nils:	Snails don't have any mouth.
Teacher:	Snails don't have any mouth?
Maria:	Yes, I've seen that.
Nils:	No-o.
Maria:	They have eyes anyway. (p. 76, our translation)

However, this topic is at this time not further followed up in the teacher-child talk. In reviewing the learning situations afterwards, in additions to the conclusions drawn from the initial mapping of the children's knowledge of insects (and other small animals), the issues of the number of legs of different animals (anatomy) as well as their living conditions (e.g., food) is decided to be given more consideration by the teachers on the subsequent occasion. The teachers also decide to introduce a categorization key, which consists of pictures and text that makes it possible to identify different species of animals (similar keys exist for deciding plants and mushrooms). During the third time they talk about insects, the children and their teachers go into the adjacent forest and look for insects. Using their categorization key, they are able to investigate under loupe the animals they find. The children are greatly enthusiastic about the possibility of analyzing the animals in terms of their number of legs and whether they have or have not got wings. Together they try to see whether the animals they find have six legs and three body parts. The children once more make drawings of the animals they have found and compare these to the categorization key.

Looking at these new drawings and listening to what the children have to say, it becomes clear, Ärlemalm-Hagsér, E (2008) suggests, that the children have developed their knowledge of animals, including anatomy and variation among animals. Nils, who previously (see above) did not think that insects had a mouth, now draws an ant while exclaiming, "But how many legs has an ant, six, 1, 2, 3, 4, 5, 6 (counting the legs he has drawn)… I drew my ant with 1, 2, 3 body parts!" (p. 79, our translation). In addition to having discerned the number of legs and body parts, his drawing depicting an ant now also has a mouth.

Concluding the study, the children's knowledge of insects and other animals can be described in terms of an increased differentiation, being able to differentiate out numbers of legs, body parts, and other features. This small-scale study also illustrates how talking about what one does (e.g., while making a drawing of an insect) provides developmental opportunities, not only between teacher and child but also between children (cf. above, the example whether insects have mouths). Working in a cyclical way, that is, following up on children's uptake and ideas on subsequent activities means that learning is not reduced to one-offs. Supporting children in making connections between these events, that is contextualizing backwards and forwards (cf. Mercer, 1995) is important in making sure the children make such connections and see how things relate to one another. Not only identifying what children know, about, in this case, insects, or provide opportunities for children to interact with each other, but also introducing mediating tools, such as the categorization key into a meaningful situation in which children engage, could be seen as an activity underpinned by a cultural-historical paradigm.

5.4.3 The (Missing) Practices of Early Childhood Science Education

In her study, Elm (2008, cf. Elm Fristorp, 2012) investigates how a natural science topic is selected and orchestrated in a preschool and a preschool class (an intermediate form of schooling between preschool and school for the 6-year-olds). A preschool group (one teacher and six children aged 2–4) and one preschool class group (two teachers and 14 children aged 5–7) were followed with a video camera when working on various natural (scientific) phenomena. In the study, data and analysis from four different activities are presented: floating and sinking, and "small creeping things under rocks" (in the preschool) and ants (Camponotus) and black woodpeckers" and a stuffed green woodpecker (in the preschool class). The emerging activities are analysed in terms of language use (speech) and natural science activities. Analysing the kinds of scientific activities the children and teachers engage in in their interaction, Elm points out that some basic acts such as 'planning', 'interpreting' and 'explaining' are missing from her data. For example, as she writes concerning an activity in preschool where it was tested whether different objects float or sank, "There is no reasoning about why objects float or sink" (p. 52, our translation). To large extent, "predicting tends to be left out when the children observe and examine whether objects float or sink" (loc. cit.). In our alternative terms, what appears missing from the activities studied by Elm is talking about what lies beyond (i.e., is more general than) the present instance (cf. Chap. 5), that is, how to explain what happened (retrospective speech) and how to anticipate what may happen (prospective speech).

The theme "Small creeping things under rocks" consists of children and their teacher making an excursion to a nearby forest. One of the activities they engage in is looking at insects under rocks. One thing that is evident in the empirical excerpts is that the teacher often responds to children's questions by posing a new question (e.g., 'What do you think?') or suggesting that they could 'investigate', take a look, rather than giving an answer to what the child asked in a more strict sense. This was also observed in Thulin's (2010) study, where she suggests that this may be an indicator of teachers in preschool nurturing an ideal of children finding out about the world through exploring it (see further, Chap. 2; cf. also our discussion in Chaps. 1 and 7 on the difference between a Piagetian and a Vygotskian perspective on learning and development, see also, Fleer, 2009a). This stance, in terms of the three paradigms introduced above, is underpinned by epistemological individualism.

One of the activities followed by Elm (2008), as we have already mentioned, was ants (Camponotus) and black woodpeckers. Having walked to a nearby forest, the children and their teachers among other things investigate a fallen tree trunk and a hollow stump surrounded by wood splinters. The teacher has brought along a book for interpreting traces of different animals. Together the teacher and the children compare the pictures in the book with the stump they look at to try to find out what may have made the wood splinters. The teacher suggests that this may have been caused by black woodpeckers trying to get to ants (Camponotus) in the stump. Elm writes:

> More elaborate explanations and reasoning about what one does and why are missing. Further activities of an investigative nature that activates the children are also missing. The teacher's comments appear to be spontaneous responses to needs at the moment. When a child answers a question, the teacher follow up the child's answer with another question that is often introduced by, Do you think… There is no sustained reasoning of an overarching kind, for example, about why the children think it can be the way they express. In the discussions that occur, the teacher appears to be making an inventory of the children's ideas. Such discussions are concluded when a child delivers the answer the teacher expects. (p. 75)

While being rather concerned with what was 'missing' from these early childhood science education practices, Elm's study does say something about what such activities consist of for the children participating, and thus what is made possible for them to learn. What learning opportunities different educational practices offer children is important to investigate with an interest in children's science learning. Rather different learning opportunities will be seen in other early childhood science education activities that we investigate in other chapters in this book.

Research into early childhood science education in the Nordic countries is much in line with the perspective taken in this book, in investigating early childhood science activities from a socio-cultural (cultural-historical) perspective with a particular focus on communication and other tool use. There is thus an affinity between this research and the research from Australia informed by a cultural-historical perspective that we reviewed in the previous section. In the next section we will look at empirical studies of, and discussion pieces on, early childhood science education from Greece and the US.

5.5 Greece: A Social Interactionist Paradigm

One of the few countries from where it comes quite a few studies on early childhood science education is Greece. In this section we will therefore review some recent and fairly recent studies that are of interest to the present book.

In his discussion of early childhood science education, Hadzigeorgiou (2001) argues that in order to establish a foundation for the child's science learning, "certain attitudes do facilitate its establishment and it would be preferable to start with helping young children develop these attitudes" (p. 64). He goes on to argue that certain attitudes towards science "are the prerequisites or the motivators for children's engagement in science activities" (p. 64). What he refers to as attitudes particularly concerns "intellectual curiosity" (p. 64). Hadzigeoriou's reasoning is made against the tradition of 'pedagogically appropriate' activities, and while he states that he recognizes this approach as sound, he suggest that it may not establish any long-term relationship between the child and science. According to this reasoning, there may be activities that are not 'pedagogically appropriate' that should still be included and emphasized in early childhood science education; these are activities that “can make children feel perplexity, wonder, amazement and surprise without the possibility of their direct action on objects and subsequent investigations” (p. 65). Some of the activities intended to incite wonder into children are: “Emptying water from one glass into another using a piece of towel cloth without moving or tilting the glasses”; “Inflating a balloon by putting it on the top of a bottle that is left for a while in the sun”; and “Making an egg float on the surface of water by putting more and more salt in the glass” (p. 65). These kinds of activities are suggested to provide “great stimulus for learning” (p. 65), especially for preschoolers. In his reasoning, Hadzigeorgiou refers to empirical observations where such activities have been conducted, but the paper contains no information on what was observed and how in more systematic terms. Hence, this paper should be considered a discussion piece, rather than an empirical investigation into early childhood science education. Referring his reasoning back to philosopher of science Alfred North Whitehead (1861–1947), who, Hadzigeorgiou writes,

> believed that in order for students to be able to reflect on knowledge that will not be inert, a certain rhythm of its presentation should be followed by teachers. To describe the rhythm he used the terms ‘romance’, ‘precision’ and ‘generalisation’. Children should begin their engagement with any subject in a ‘romantic’ way, i.e. in a way that makes them feel the excitement inherent in the subject. (p. 66; cf. Rule, 2007)

Asking himself how such ‘romance’ could be induced, Hadzigeorgiou suggests through stories. It is further suggested that through, for example, a story about the tension between ‘hot’ and ‘cold’, the child will learn the concept of ‘cool’ (p. 67). However, from our point of view, it does not seem clear how “binary opposites” such as “energy as something good and energy as something bad” (p. 67) would develop children’s understanding of energy as a science concept. And building on the works of Bruner (1990, 2006; as also, albeit briefly mentioned by Hadzigeoriou), the differences and complex relationship between a narrative account and a paradigmatic (scientific) one needs much more theoretical elaboration and empirical study. Still, with these comments, the importance of nurturing children’s interest in the phenomena of nature (as explained by science) should not be underemphasized; we will return to this issue from a different point of view in Chap. 11.

How to initiate preschool children to science is also the topic of another paper, by Ravanis and Bagakis (1998). The problems of this paper are how an appropriate curriculum for preschool could be developed and what teaching strategies should be used. Contrasting what is referred to as an “empiricist” perspective (a kind of object-manipulation and instruction approach) with a sociocognitive (Doise & Mugny, 1984) one, the authors argue the merits of the latter; such as the importance of social interaction and negotiation between partners. More specifically, this approach is said to hold merit over the alternative due to the communication between the children “leads to the decentration from the subjective perspective” and children “facing the arguments of a collaborator understand that for a question of a problem there are many possible solutions, consideration and strategies of dealing with it” (p. 319). Hence, a social interactionsist paradigm underpins the discussion. Following their reasoning about different approaches to early childhood science education, Ravanis and Bagakis illustrate a teaching sequence concerning the gasification of water.

Exploring preschool pedagogic practices related to science, Tsatsaroni, Ravanis, and Falaga (2003) use sociology of education theorist, Basil Bernstein's work to argue and illuminate that "the emergent discourse of pre-school teaching and learning of specialized content is in tension with dominant pre-school pedagogic practices, and that the contradictory demands placed upon teachers" to focus more on science content, on the one hand and to provide a play-based activity on the other "might lead to a narrowing of the view of learning in pre-school classrooms" (p. 385). This perspective is used to discuss a pilot study conducted in nursery school on magnetic properties and materials susceptible and not susceptible to magnetic attraction. Tsatsaroni et al. (2003) argues that this emerging tension between discourses place contradictory demands on the teacher:

> Thus, pre-school teachers might shift between a pedagogy that constructs weak boundaries between specialized school knowledge and everyday knowledge, based on the ideological notions of play and activity as a means of developing the child, and characterized by slow pacing, invisible criteria and interpersonal forms of control; to one which constructs strong boundaries, puts an emphasis on 'lesson' as specialized content, and is characterized by strong pacing, and too narrow criteria of evaluation of the practice (and pupils). (p. 412 f.)

If so, this would fundamentally rearrange the nature of early childhood (science) education.

In an experimental study, Ravanis, Christidou, and Hatzinikita (2013) investigated children's understanding of light. Two groups of in total 170 preschool children (approximately 6 years old) were studied, with pretest, teaching intervention and post-tests. One group of children participated in activities built on the principles of a sociocognitive approach, while the other group participated in activities on the basis of what is referred to as "an empiricist perspective" (p. 1). In the sociocognitive group, "a familiar metaphor was introduced in order to facilitate children to construct a 'precursor model' about light" (p. 1); the metaphor being "the travel of light through space" (p. 9). The distinction made between the two approaches is explained as "The empiricist approach is based on the conviction that the provision of organized stimuli (activities) to children can ensure learning while the sociocognitive approach attempts to support children in constructing a precursor model based on the use of a familiar metaphor" (p. 4). The findings indicate that both groups of children developed their understanding of light from pre- to post-tests but that the "cognitive progress" (p. 1) made by the children in the sociocognitive group was more significant than the progress made by the children in the empiricist group. "These results," Ravanis et al. (2013) suggest, "indicate the significant contribution of the teaching activities involving interactions that were structured around the existing obstacles to children's cognitive development" (p. 17). Hence, this study serves to emphasize the important role of others, including the teacher, not only for organizing the environment for children but also for reasoning with children.

5.6 The United States of America: An Individualistic Paradigm

From an American point of view, Baldwin, Adams, and Kelly (2009) suggest that many early childhood teachers "are struggling with the notion of how to blend an instructional focus on academic content standards with the National Association for the Education of Young Children's (NAEYC) 12 Principles of Learning and Teaching that have been identified as preferred practice for the field" (p. 71 f.). Against this background, Baldwin et al. describe "an approach used by one university supported demonstration school to develop an assessment supported, child-centered, and emergent curriculum framework that addresses both preschool content standards and developmental domains" (p. 72). Central to "emergent curriculum", they suggest, is "maintaining a commitment to build instruction on children's interest" (p. 72). While the importance to build upon children's interest and sense-making is important; we would argue that institutions such as preschool and school are also a society's way of ensuring that children are introduced to fields of knowledge and develop new interests than they would have in their home environment. Furthermore, taking a Vygotskian perspective, typically institutional forms of knowledge such as 'scientific concepts' (Vygotsky, 1987) build on other principles – abstract systems made up by relations between concepts – than what the child has experiences of. This does not mean that the child's previous experiences are not important to appropriating such institutional forms of knowing, but the relationship is complex (we return to this issue throughout this book). About the demonstration school, Baldwin et al. (2009) write: "Based on a sound understanding of child development and learning, the team determined that the most engaging and therefore most efficient way for young children to learn is when instruction builds upon their interest. Staff believed that topics of learning are best garnered through the ideas, excitement, and questions of the children themselves" (p. 72). This reasoning is underpinned by an individualistic paradigm, but, as we have already hinted at, the possibilities of building on children's interest and/or also having to interest children to new forms of knowing and phenomena is a complex issue that needs to be considered. In addition, as we will discuss in some length in Chap. 11, asking questions is in itself something that children develop through participation in an activity – or a prolonged theme/project – rather than necessarily having beforehand. "Children's natural curiosity with the world around them and the questions they ask often related to science concepts", Baldwin et al. suggest about the children in the demonstration school they write about. To encourage exploration in the children, naturally occurring events, for instance, finding worms after it has rained, were used as starting points. What is referred to as a 'science concept planner' is then constructed by the teachers, starting with the science concept, its related concepts and materials and standards relating to these concepts are identified. This approach, they write, "differs from the common practice of choosing activities and then determining what can be learned from them" (p. 74). During children's exploration, their progress is documented by the teachers and displayed on a project board and in children's individual portfolios.

In a statistical study, based on longitudinal data with over 8000 children, Saçkes, Trundle, Bell, and O'Connell (2011) investigated the impacts of selected early science experiences in kindergarten on children's achievements at the beginning and end of kindergarten and in third grade. The availability of science materials was found to facilitate teaching of science and children's participation in such activities. "Children's engagement with science activities that involved using science equipment", Saçkes et al. report, "was not a significant predictor of their end of kindergarten science achievement. However, children's participation in cooking activities was" (p. 217). Summarising their results, Saçkes et al. suggest that their study indicates that "early childhood experiences provided in kindergarten are not strong predictors of children's immediate and later science achievement" and that this limited effect may be due to "the limited time and nature of science instruction" (p. 217) in kindergarten. What is in the study referred to as "science materials" are exemplified with "water and sand table, and science or nature area with manipulatives" (p. 220). However, these materials and environments do not say anything about how they were used or engaged with, and therefore, whether science activities evolved, we would argue. For example, concerning "children's science activities" with "science equipment (e.g., magnifying glass, scales, thermometers) and cooking and food related items" (p. 222), the following is stated:

> Using a magnifying glass to examine insects or rock samples, measuring quantities and temperature, and using food related items to develop measuring skills and to study properties of matter are typical science activities in kindergarten classrooms, and these activities involve scientific skills. Therefore, these variables were used as the indicators of children's science activities in the study. (p. 222)

A study of this kind raises many questions. Whether it is sound to measure children's science scores in kindergarten must surely be questioned. Furthermore, the issue of testing children's understanding is a very complex issue (see e.g., Chap. 7 of this book for a discussion). It must also be questioned if more science teaching (as estimated by the teachers) is necessarily better, that is, more developmental for children than the nature of such teaching. For a forceful argument to the contrary, that it is how teachers and children communicate in science activities that is decisive, see Fleer (1995; see also, Gustavsson & Pramling, 2014). In fact, Saçkes et al. (2011) themselves suggest that "future studies also should examine the nature of teacher – child interaction in science learning in early years" (p. 229). "Children do not learn science in early years because few science learning opportunities are provided for them" (p. 230) with the majority of the teachers of Saçkes et al.'s (2011) study report that they teach science once or twice a week.

In a discussion piece, Brenneman and Louro (2008) argue that what they call 'science journals' can be used in preschool for supporting and assessing children's science and literacy learning (cf. Chang, 2012). They also discuss the importance of teachers talking with the children about their journal entries (primarily drawings), suggesting that "[f]rom a Vygotskian perspective, teachers model the sorts of questions children may ask themselves as they record observations, providing a scaffold for children's learning" (p. 115). Furthermore, representing observations in journals may motivate children to observe attentively, providing an incentive for doing so.

5.7 Conclusion

As seen in the review we have made in this chapter, early childhood science education is today a concern for research and scholarly debate. What was shown was that there were different perspectives on how such education should be organized to provide for children's learning, and research in this field is informed by more or less distinct theoretical traditions – individualistic paradigm; social interactionist paradigm; and cultural-historical paradigm

It can be argued that scientific knowledge can be conceptualized as being located within specific areas of everyday life, such as school knowledge, work-based knowledge, or knowledge about how to do things at home. In this conception, knowledge encompasses practices where problems arise and solutions need to be found, where goals are met, and new possibilities created. As suggested by Hedegaard and Chaiklin (2005) "General knowledge refers to that knowledge which is used commonly to address these [problems, goals, possibilities] needs" (p. 52). General forms of knowledge that are created in one arena, and which have evolved over time and used in another arena, are forms of *societal knowledge* (Hedegaard and Chaiklin).

In the science education literature reviewed, knowledge construction is about a specific form of societal knowledge often named as subject-matter content or academic knowledge or discipline knowledge. But these forms of knowledge cannot be considered as independent of what Hedegaard and Chaiklin (2005) have called *local knowledge*. In their conception, local knowledge is a kind of knowledge that is created at home and in the community. This was evident in the studies reviewed in this chapter on early childhood teacher knowledge of science, where specific localized ways of teaching and learning featured as an important finding – such as play based programs.

What also featured in this chapter was the significance of personal knowledge of the early childhood teachers. Personal knowledge is similar to Vygotsky's (1987) theory of everyday concepts and science content knowledge as related to Vygotsky's theory of scientific concepts (see Chap. 1). How teachers and children related to the science content knowledge and turned this into personal knowledge, was featured as important in the Australian studies, but few concentrated upon how to solve this problem. This line of enquiry was more evident in the Nordic countries, for example, in terms of how to respond to children's questions (see also further our empirically-based discussion about the latter matter in Chap. 11). While the Nordic studies generally were underpinned by what we refer to as a cultural-historical paradigm, findings from early years practices illustrated how teachers may base their pedagogy on an individualistic paradigm. This line of inquiry was non-existant in the studies undertaken in Greece, and only slightly touched on in the US, where an individualistic paradigm for framing research was prevalent.

Both societal and personal knowledge interacts with subject matter knowledge (Hedegaard & Chaiklin, 2005). The nature of this interaction should allow subject matter knowledge to become personal knowledge for the child to use in everyday life, and not just in school contexts. According to Hedegaard and Chaiklin (2005) "How children's personal knowledge from home and community life will be related to academic knowledge in school depends on the form of academic knowledge and the teaching practice" (pp. 52–53). In the next chapter we take up this challenge and examine teaching pedagogy in early childhood settings where narrative, empirical and theoretical knowledge emerge as a result of the practices and beliefs of the early childhood teachers.

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