Chapter 9
Kindergarten as a Budding Explorative Scientific Community

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9.1 Introduction

Major public policy issues, such as fighting climate change, feeding the world's growing population, preservation of biodiversity, and demand for sustainable development, require scientifically-educated and informed citizens more than ever before. Today there is a growing focus not only on the need for scientifically-knowledgeable experts, but also on the need for a scientifically-literate population in general, in order to have a well-functioning democracy. I quote the Committee on Science Learning, Kindergarten Through Eighth Grade: "A well-functioning democracy demands that its citizens make personal and community decisions about issues in which scientific information plays a fundamental role, and they hence need a knowledge of science as well as an understanding of science methodology" (Duschl, Scweingruber, & Shouse, 2007, p. 34). According to this view, the overriding aim of science education is to give every person the opportunity to take part in society, both when it comes to their career choices and when it comes to understanding and taking a stand on information related to socio-scientific questions.

Albert Einstein claimed: "The aim (of education) must be the training of independently acting and thinking individuals" (Einstein, 1966, p. 39). This statement is in accordance with governmental views on educational goals today, both in science education and in education more generally (National Research Council, 2012; OECD, 2018). The key question is then: 'How do we train or cultivate our children to become independently thinking and acting individuals?' There is no simple answer to this question but focusing on *science as inquiry* and the *practices of science* is one suggestion given by the scientific educational community (Crawford, 2014; Osborne, 2014).

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In keeping with current educational views that kindergarten is the first step in a child's education, kindergarten is included in policies and strategies for promotion of science and emphasized as an important arena for children's first experiences with science in several countries, including Norway (Kunnskapsdepartementet, 2015; National Research Council, 2012). The aim is that children's early experiences with science can stimulate and nurture their interests in science and lay a foundation for future science learning in school.

Several authors maintain that science is in a privileged position as a learning area in the early years because it coincides so naturally with children's sense of wonder and their curiosity to learn about the world around them (Eshach & Fried, 2005; French, 2004; Nayfeld, Brenneman, & Gelman, 2011). The Committee on Science Learning, Kindergarten through Eighth Grade, points to the fact that research show that young children *are* capable of complex thinking about science ideas and *can* engage in a range of science inquiry skills (Duschl et al., 2007). Eshach, Dor-Ziderman & Arbel (2011) assert that if we ignore the training of such skills in early years, we are missing an important opportunity for developing and expanding young children's scientific thinking.

Despite current understanding of the importance of supporting children's early interest in science, studies in both Norway and in other countries show that science-related activities are given low priority in kindergartens (Greenfield et al., 2009; Kallery & Psillos, 2002; Kallestad & Ødegaard, 2013; Saçkes, 2014; Tu, 2006). Various reasons are given to explain this. One is that kindergarten teachers' low level of scientific knowledge causes low self-confidence in teaching science (Andersson & Gullberg, 2014; Kallery & Psillos, 2002). High political focus on language and mathematics as learning areas and consequently little time spent on science activities is another factor discussed (Greenfield et al., 2009). A third reason could be a view on science and science education as mainly dealing with conceptual learning using teaching methods not considered as good educational practice in kindergartens (Andersson & Gullberg, 2014; Sundberg & Ottander, 2013).

The aim of this article is to contribute to a discussion on how science education can be put into practice in kindergartens in a way that strengthens children's interest in science and lays a foundation for developing scientific reasoning and thinking. I argue in favour of an approach in which children have opportunities to take part in a budding scientific community, characterized by children's and teachers' shared exploration of scientific phenomena and objects.

9.2 Learning and Development from a Cultural-Historical Perspective

As is the case in the rest of the book, this chapter is framed within cultural-historical theory of child development as originally formulated by Vygotsky (1998). As I see it, Vygotsky's theory as well as other socio-cultural theories, underpin a science education in which children are given opportunities to participate in a community where exploration of scientific phenomena and objects is distinctive. There are two interrelated ideas from Vygotsky ‘s work that I find especially relevant in this connection:

I. Social activities as starting point of learning and development.
II. Learning and development as mediated.

9.2.1 Social Activities as Starting Points of Learning and Development

Vygotsky claims that learning and development are results of social interactions. This is a fundamental break from the traditional and individual oriented psychological view that inborn development of the individual is central, while the environment constitutes a more or less important source of influence. To Vygotsky, social interactions are the starting point of learning and development, not only a frame for individual processes; the development does not start as an idea in children’s brains, thinking and ideas grow during participating in activities. He claims: “Every function in the child’s cultural development appears twice: first on the social level, and later, on the individual level; first *between* people (*interpsychological*), and then *inside* the child *(intrapsychological*)” (Vygotsky, 1978, p. 57). This implies that if we want children to develop distinct abilities, we have to include and engage children in cultures where such abilities are prominent.

Further, Vygotsky emphasizes that the societal interactions that ground individual cognition are embedded in a culture within a historical frame. This implies that participating in social activities formed by cultural-historical traditions grounds development and cultural formation of the individual. The various cultural communities that children belong to provide meanings and reference points that children use to make sense of themselves and of the world around them (Backshall, 2016). From this point of view, one must ask what kind of societal institutions or communities children belong to and what activities dominate these institutions in order to describe and understand the conditions for a child’s learning and development (Hedegaard, 2009).

Turning to science education in kindergarten, rather than focusing on what an individual child knows about the world around him or her, we ought to focus on the kind of science related activities that children are given opportunities to participate in (Roth, Goulart, & Plakitski, 2013). As I see it, this implies that children should be given opportunities to take part in a kindergarten culture in which practices of science, such as wondering, asking questions, planning investigations and trying to find out things in the world around them, are prominent. Fleer & Pramling (2014) put it this way: “If children are to learn to think and act scientifically, they need to experience a scientific environment” (p. 25).

9.2.2 Learning and Development as Mediated

An important perspective in Vygotsky's work is the view that learning is a precursor that pushes development (Vygotsky, 1978). He introduces the term *zone of proximal development* to highlight the fact that children can do or manage more with assistance from others than they can manage on their own. A child's zone of proximal development is defined as: "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers". (Vygotsky, 1978, s. 86). This suggests a science education in kindergarten in which children are stimulated and challenged cognitively, practically and socially. It also suggests an active role for the teacher in which she/he is a co-researcher as well as a co-constructer of scientific knowledge.

Vygotsky (1978) emphasizes that learning and development are mediated through culture-specific language, tools and activities. He underlines that language is both a means of communication and an individual psychological tool for thought and development. From this perspective, children's learning and development depend on society's ability to give children the words and concepts necessary to develop language as building blocks for thought.

Vygotsky (1962) distinguishes between everyday concepts (also called spontaneous concepts) and scientific concepts (also called academic or non-spontaneous concepts). The two groups of concepts differ in the ways in which they are introduced, learned and developed. Everyday concepts are the concepts that children learn in everyday life as a result of direct interaction with the environment. At the early stage, children are not very conscious of the meanings of the words, and the spontaneous concepts are unsystematic and closely connected to a specific situation. Scientific concepts, on the other hand, are concepts constructed and used in academic communities on a systematic, theoretical level. Normally, scientific concepts are introduced to children in school. Vygotsky claims, however, that everyday concept formation and scientific concept formation are strongly connected to each other and argues that everyday experiences and concepts lay the foundation for school-based academic learning (Vygotsky, 1962). The significance Vygotsky puts on children's early authentic experiences and everyday concepts for learning scientific concepts is expressed in the following quote:

> Practical experience also shows that direct teaching of concepts is impossible and fruitless. A teacher who tries to do this usually accomplishes nothing but empty verbalism, a parrot-like repetition of words by the child, simulating a knowledge of the corresponding concepts but actually covering up a vacuum. (Vygotsky, 1962, p. 83)

This points to the importance of providing children with a variety of everyday experiences related to scientific phenomena and objects, as well as a rich everyday language related to these experiences. Through teachers' guidance during scientific activities, children will gradually develop higher levels of word meanings and scientific understanding.

When discussing mediators related to children's learning, it is also relevant to consider artefacts and objects that are available in the kindergartens and how they are used. Ødegaard (2012) claims that artefacts in the everyday life of kindergartens constitute important conditions for children's learning and cultural formation. Artefacts are not neutral objects; they are made for a specific purpose, they have a name, and they have a cultural and historical background. From this point of view, it is important to consider the availability and use of science-specific artefacts in kindergartens. By taking part in activities including use of science-related artefacts such as magnifiers, binoculars, balance scales and science related books, children can be included in a scientific culture and way of thinking dominated by curiosity and exploration.

Teachers' attitudes and the tasks and activities they introduce are also strong mediating factors in kindergarten communities. If we want children to develop abilities and attitudes such as wondering and asking questions, these abilities have to be present as cultural phenomena in children's environment (Fleer & Pramling, 2014). Children in the early years are imitators, and therefore teachers who model attitudes as raising questions and eagerness to investigate and find out of things create in children a desire to do the same.

Haddzigeorgiou (2001) claims that children's wonder is an important factor in developing an affective attitude to science. Wonder can be described as an affective emotion, a kind of arousal, which may motivate the asking of questions and the carrying out of investigations. She claims that children's science learning has to be considered from a long-term perspective, and consequently, it may be more important to develop an affective attitude to science than to focus on learning skills and concepts. We may think of wonder and curiosity as innate qualities we all share, but from a cultural-historical perspective, these qualities can also be learned and stimulated by participation in social communities in which such qualities are prominent (Fleer & Pramling, 2014).

9.3 The Concept of Exploration

With references to influential philosophers in early years education as Froebel, Piaget and Rousseau, Murray (2012) claims that exploration has been advocated as an important medium for young children's learning in early childhood education for centuries.[1] She states that exploration often is referred to as a programmed ability or process in young children, from which children develop knowledge, skills and understanding. Laevers (2000) argues that investing in the preservation and strengthening of children's *exploratory attitude* and *exploratory drive* is the best guarantee of a lifelong learning process. He describes exploratory attitude as an openness and alertness to the wide variety of stimuli in our surroundings and exploratory drive as

[1] The historical roots of *exploration* are also elaborated in this book, Chaps. 2 and 7.

an urge to investigate and find things out. Furthermore, he states that such abilities can bring a person into a state of deep concentration and involvement, which may result in deep-level learning.

One important point of discussion related to children's exploration is how and to what degree teachers should be involved in the explorative processes. Laevers (2000) points to important interventions by the teachers, such as suggesting activities to children, offering materials that fit in in an ongoing activity, inviting children to communicate, confronting children with thought-provoking questions and giving them information that can capture their mind. These factors coincide with factors identified as decisive for children's exploration in a study conducted by Murray (2012). However, Murray's study also shows that children's exploration can be restricted by requirement imposed by the teachers.

Various institutional traditions understand children's exploration in different ways and consequently provide children with various opportunities to explore. (Chap. 2). Results from a comparative study conducted by Hammer & He (2016) exemplify that the interpretation of children's exploration may be influenced by culture and tradition. Focusing on preschool teachers' approaches to science education in a Chinese and a Norwegian kindergarten, they found that both the Norwegian and the Chinese teachers emphasized the idea that children should be given opportunities to explore as one of the main objectives for science education in kindergarten. The meaning of exploring seemed, however, to be somewhat different for the two groups of teachers. The Chinese teachers maintained that children should be curious, solve problems, experiment, try out ideas, classify, and record. These objectives indicate that the intended outcome of the exploration process was to develop investigative skills. In contrast, the outcome of the exploration process seemed not to be a central concern in the Norwegian kindergarten. The Norwegian teachers' notion of exploring seemed primarily to be related to children's autonomous experience of nature using their senses. The authors conclude that the Norwegian teachers' objective for the exploration process was for the children to develop a relationship with nature and an appreciation for, and enjoyment of, the natural world (Hammer & He, 2016).

In the newly revised Norwegian Framework Plan for Kindergartens (UDIR, 2017), children's exploration is emphasized throughout the whole document. The plan does not, however, elaborate on what is meant by *exploration*, which leaves room for different interpretations as to how children's exploration is understood and put into practice in the everyday life of kindergartens.

From a science education perspective, *children's exploration* coincides with *science as inquiry* and *practices of science,* which are the two dominating perspectives on science education today (Crawford, 2014; Osborne, 2014). It also coincides with the concept of *sciencing* introduced by Neuman (1972) to signify the importance of children's involvement in the processes or practices of science.

9.4 'Science as inquiry' and 'Practices of science'

Traditionally, science education has dealt with teaching distinct elements of accumulated scientific knowledge (*science as a product*). Today, however, good science education is associated with focus on the scientific methods or practices used to develop scientific knowledge (*science as processes*). *Science as inquiry* and *practices of science* are central perspectives in international governmental documents and strategies to improve science education from kindergarten to high school (K-12) (National Research Council, 2012). There is emphasis on the fact that science is undertaken by communities of researchers and that scientific knowledge is a socially negotiated, culturally embedded product.

In reform documents *Science as inquiry* has been a dominant approach in science education for about 50 years (Abd-El-Khalick et al., 2004; Crawford, 2014). However, even today science education in schools and kindergartens primarily deals with established knowledge and to a lesser extent the practices of science (Abd-El-Khalick et al., 2004; Kallery, Psillos, & Tselfes, 2009). The reason for this is likely to be complex. One reason highlighted in recent literature is that science as inquiry reflects a confusion of meanings and goals. Crawford (2014) advocates the following definition for teaching science as inquiry:

> Teaching science as inquiry involves engaging students in using critical thinking skills, which includes asking questions, designing and carrying out investigations, interpreting data as evidence, creating arguments, building models, and communicating findings in the pursuit of deepening their understanding by using logic and evidence about the natural world. (Crawford, 2014, p. 515).

Regardless of the various meanings of inquiry, there should in all cases, be a central guiding question that leads investigation and exploration. Engaging children in investigations to find out things related to the natural world should be the centrepiece of science education. This is relevant for science education in kindergartens as well as in schools.

Instead of presenting science as inquiry, some reform documents define science education from kindergarten to high school in terms of eight *practices of science* that guide scientific reasoning and sense-making. The Framework for K-12 Science Education (National Research Council, 2012) cites the following eight practices to be included in science education:

- Asking questions.
- Developing and using models.
- Planning and carrying out investigations.
- Analysing and interpreting data.
- Using mathematics and computational thinking.
- Constructing explanations.
- Engaging in argument from evidence.
- Obtaining, evaluating and communicating information.

These eight practices are cultural-historical practices that dominate scientific communities and today it is generally thought that the best way to learn science is for children to be engaged in these practises.

Some of the practices such as asking questions, planning and carrying out investigations, discussing and argumentation may be just as relevant for children in kindergartens as for schoolchildren. However, practising science must take different forms in kindergartens than in schools. In schools, the practices of science have to be related to distinct content described in the relevant curricula. In kindergartens, science practices should relate to experiences in children's everyday life (Gomes & Fleer, 2018; Roychoudhury, 2014). The kindergarten curricula and guidelines are normally broad frameworks, which implies that the content in focus as well as the time spent on work with a theme can be open for children's motives and interests.

9.5 Sciencing in Kindergarten

Discussing science education in kindergarten, Neuman (1972) introduces the concept of *sciencing*. By verbalising science, he denotes the importance of children's involvement in practices of science. Neuman describes sciencing as activities where children are "given a chance to observe and manipulate a variety of artefacts and natural objects in ways that help them to recognize similarities, differences and relationships among the objects and phenomena" (Neuman, 1972, p. 137–138). He emphazises that in the process of sciencing children should be encouraged to extend their thinking beyond their immediate observations and discuss what they are doing and what they are observing with teachers and peers. Neuman highlights four practices of science that are particularly relevant in kindergarten: observing, inferring, classifying and communicating. Observing is highlighted as the most basic process as it is a building block for the other processes. Furthermore, he describes three categories of science activities in kindergarten: *incidental sciencing*, *informal sciencing* and *formal sciencing*. These categories have been subsequently used in analyses by researchers as Tu (2006) and Fleer, Gomez & March (2014) among others. In this section, I elaborate on the characteristics of *kindergarten as a budding explorative scientific community* based on Neuman's three categories of sciencing. I also reflect on what competences or qualities kindergarten teachers need to facilitate various sciencing activities.

9.5.1 Incidental Sciencing

Incidental sciencing is the result of an unplanned sudden occurrence that captures the imagination of one or more children, and which is capitalized upon by the teacher (Neuman, 1972). I will use a personal experience with two grandchildren as an example:

> Jacob (3½ years old) and Mari (5 years old) had just moved from Norway to Texas with their family. My husband and I were over from Norway visiting them. One day on our way to the supermarket, we discovered a dead animal laying on the street close to the pavement. We drove past but the children started asking: "What could have happened to the animal? What kind of animal was it? Could it be a cat or a dog?" We decided that we should stop and go out of the car on our way home to take a closer look (luckily, the road was a smaller one and not loaded with heavy traffic). When we approached, we saw two huge birds flying up from the dead animal and positioning themselves in the tops of two high pine trees, and we noticed a strange smell. This gave rise to new questions: "Why was there such a strange smell? What did the birds intend to do? What kind of birds were they?" When we came close, we could see that the dead animal was quite crushed, and we concluded that it probably had been hit by a car. New questions: "Where did the animal come from? Why was it on the road? Where does it normally live?" Neither the children nor I had seen such an animal before. Even though it was crushed, we could see that it had a kind of carapace on the back or seemed as if it was plated all over. When at home, we searched for 'animals living in Texas' on the internet. We looked at many pictures and after some discussion we concluded that the dead animal was an armadillo and the two birds where vultures. During the rest of our visit, the children and I repeatedly discussed questions related to this incidental event.

This story shows how everyday incidents can engage children and stimulate interesting questions, which can form the basis for further investigations. The decisive issue is for the teacher to grasp this kind of incidences and encourage the children to engage in a process where both children and teachers wonder and want to find out more. Teachers' own curiosity and their willingness to investigate the situation may be more important than their subject knowledge. When children ask: "What is this? How can this be?" it should be ok for the teacher to answer: "I don't know, but let's try to find out" (Tu, 2006).

Teachers should themselves be attuned and receptive to incidental episodes with sciencing potential. These could be a huge rainbow emerging on the sky above; birds singing on an early spring morning; icicles on a rocky wall in winter; or the teeming life in an anthill on a warm summer day. By showing their own wonder in such situations, teachers can call attention to natural phenomena that children may not themselves recognize (Fleer, 2009). Wonder and curiosity are contagious: if teachers see, listen, smell and touch, children will do the same. If experiences like those I have presented above are to be more than a here-and-now experience, they need to be elaborated in various ways and to be given attention over time. Fleer & Pramling (2014) underlines that wonder without further exploration may imply lost opportunities for learning. To follow up and extend the experience of the phenomena in kindergarten settings, teachers could for example, take pictures to use as documentation and starting points for experience-sharing and further exploration.

An important role for teachers (not only related to incidental sciencing, but to sciencing in general) is to use words relevant to experiences that could expand children's vocabulary and give them tools for thinking and communicating about the phenomena under consideration. Teachers should use their language in a natural way that relates to their experience of the authentic situation, but keep in mind children's abilities to give meanings to the words. For example, with young children experiencing icicles for the first time, the teacher might choose to use words such as *ice*, *icicle* and *cold*, while older and more experienced children could be introduced to process words as *freezing* and *melting*.

9.5.2 Informal Sciencing

According to Neuman (1972), informal sciencing takes place when children manipulate and explore selected materials on their own. One key issue here is the quality and quantity of available materials. These could be magnifying glasses, scales, magnets, simple electrical equipment, floating and sinking materials, and various devices in the outdoor playground.

I will share a passage from a report by one of my kindergarten teacher training students, which illustrates how the availability of magnifying glasses can stimulate children's exploration:

> In my kindergarten both the kids and the staff were interested in insects and other creepy-crawlies. One day we found a dead fly and a living spider inside the kindergarten. We caught them in a box with magnifier on top, so that we could see the small animals from different angles. Some of the kids were very engaged and I was surprised for how long time they kept on studying. The spider was let free in the afternoon, but the dead fly was kept in the box and studied the next day as well. (Kindergarten teacher training student)

Another key issue is that of how materials and equipment are introduced to children. Nayfeld et al. (2011) claim that science materials and artefacts can stimulate children's exploration because they both suggest and support scientific investigation. The researchers demonstrated, however, that adult-guided interventions are a critical factor in children's autonomous use of available science-related materials. They studied the amount of time that 3–5-year-old children spent using available science materials in the classroom during their free choice time, both before and after introducing a balance scale and showing how to use it. Baseline observations showed that children and teachers rarely spent time in the designated science area. However, after the teacher had introduced how to use a balance scale available in the science area, children's presence in the science area and their autonomous use of the scale increased dramatically. Observations of the children showed that they used their new knowledge from the given intervention during play. The children who were introduced to the scale also scored higher in a post-intervention knowledge interview than peers in a control group. The study shows that availability of science materials in itself is no guarantee of a high degree of sciencing; the potential in such materials depends on how teachers introduce and use the equipment and materials.

Kindergartens in Norway and other Nordic countries traditionally spend a lot of time outdoors (Moser & Martinsen, 2010). Spending time outside in nature can be an excellent opportunity for informal sciencing; children can gain a lot of first-hand experiences with plants, animals and other phenomena in an authentic context. They can explore creepycrawlies, flowers, icicles or whatever that catches their interest. However, there is a risk that we take children's exploring and learning outdoors for granted (Gustavsson, Jonsson, Ljung-Djãrf, & Thulin, 2016). Again, teachers should be aware of their position as role models. They should touch bark, moss, ice, and express how it feel. They should lift stones to find creepy crawlies, savour flowers, and listen to birdsong. Another important role of the teacher is to pay attention when children express their curiosity and to enter into a dialogue with them in order to nourish their interest and expand their understanding. Knowledge, in the form of useful generalizations, does not simply emerge from casual observation and experiences. If observations and experiences are to be developed into knowledge and understanding, children need to have a partner to communicate and discuss them with (Fleer & Pramling, 2014; Hammer & He, 2016; Hedges & Cullen, 2005).

9.5.3 Formal Sciencing

Formal sciencing (Neuman, 1972) refers to science activities carefully planned by the teacher but still open to children's influence. The shift from informal to formal sciencing can be gradual, but in general, planned science activities involve the teacher having more specific goals, introducing the activities, and structuring these activities at least part of the time. The goals may be for the children to develop skills related to the practices of science, or to develop conceptual knowledge about a specific scientific content. Formal sciencing may take various forms. It could involve guiding children in doing experiments focusing on practices such as asking questions, planning how to find things out, observing, reflecting, and communicating. It could also involve working with themes such as 'the weather', 'birds during different seasons" or 'my body' over a longer period. The actual theme has to be meaningful and authentic for the children. It may be chosen because some of the children express interest in that theme, or because a staff member finds it interesting and believes from experience that the children also will find it interesting.

As I see it, formal sciencing may have some important advantages. One advantage is that the staff can cooperate and prepare themselves. They can find out about the theme in focus before introducing it to the children, they can discuss which activities will be appropriate, and they can reflect on what the children should learn from the activities and which key words and concepts the staff should use in dialogues with the children. Another advantage is that all children can be included in the activities. Incidental sciencing and informal sciencing may favour children who often ask questions and get teachers' attention, while others who catch the teachers' attention less frequently can fall short in being involved in the practices of science. Formal sciencing may result in more equally distributed science experiences and learning.

9.6 Bridging and Challenging Beliefs about What Constitute Good Educational Practices in Kindergarten

Everyday activities in kindergartens depend on cultural traditions, societies' views on childhood, and on how we think children learn (Hedegaard, 2009). In this section, I argue that an approach to science education based on children's and teachers' shared exploration of scientific objects and phenomena, has the potential to both bridge and challenge various understandings of what constitute good educational practice in kindergartens.

In an international context, the Norwegian kindergarten (together with kindergartens in the other Nordic countries), has traditionally been part of a social pedagogical tradition with a strong focus on children's psychological and social development. Children's school readiness in the form of academic learning has been less focused as an expressed objective than in countries that situate kindergarten within a more academic tradition (Ackesjö & Persson, 2016; Alvestad, 2004; OECD, 2006, 2012). The pedagogy in the Nordic kindergarten has been and is still child-centred in the sense that children's interests and perspectives are central, and children have a lot of time to play and explore what they themselves find interesting, without too much interference form the teachers (Einarsdottir, 2006; Hammer, 2012; Strand, 2006; Wagner, 2006). However, during the last decades, kindergarten have changed from being part of the welfare system to being part of the educational system, which has meant a stronger focus on children's learning. In Norway political and social expectation about the content and tasks of kindergartens is incorporated in the *Framework Plan for Kindergartens – Contents and Tasks* (UDIR, 2017). The framework plan expresses a holistic view of learning that focuses on the development of the whole child. The concept of learning is closely related to socialization, care and upbringing in addition to the development of knowledge, skills and attitudes in seven various fields of learning, one of which is *nature, environment and technology*. The learning areas are, to a certain extent, the same areas that children will encounter again as subjects at school. As such, there is a connection between the Framework Plan for kindergartens and the curricula for Norwegian primary schools and an idea that children's experiences with the various learning areas in kindergarten can lay a foundation for their later learning in school. Today kindergarten teachers as well as scholars within the kindergarten educational community discuss how to implement the strengthened educational focus without losing the child-centred perspective and without making kindergarten school-like.

One issue at stake here is that of developing basic competences versus learning subject-specific knowledge. As I see it, teaching *science as practices*, supports learning and development of basic competences as well as scientific conceptual knowledge. Practises such as asking questions, investigating, explaining, and arguing can stimulate critical thinking and meaning making which are important basic competencies. Developing investigative skills require a substantial content to work on. By directing the investigations to natural phenomena and objects catching children's interest, children will acquire subject-specific content knowledge as well.

Another issue at stake is child-centred pedagogy versus a more teacher-led pedagogy. The strong focus that cultural-historical theory puts on teachers' roles may challenge a more child-centred pedagogy. Traditionally, from a child-centred viewpoint, children's exploration is related to children's autonomous freely chosen activities. It is assumed that children will explore, discover, and learn about the world around them if given stimulating surroundings. From this perspective, the teachers' role is primarily to prepare stimulating and engaging surroundings. From a cultural-historical perspective, however, the teachers' role is more prominent. Besides preparing a challenging environment, the teacher should be a co-researcher and co-constructor of scientific knowledge, as well as a role model showing his or her own curiosity and eagerness to find out about things of interest (Cutter-Mackenzie, Edwards, Moore, & Boyd, 2014).

9.7 What Competences Do the Teachers Need?

Obviously, three years in kindergarten teacher education (as in Norway) cannot make teachers experts in all the learning areas children are supposed to encounter in kindergarten. By focusing on science education in kindergarten based on the *practices of science*, qualities and competences other than teachers' scientific content knowledge may be more important. The most important quality the teachers need to create kindergarten into a budding explorative scientific community is a sciencing or scientific attitude, which in short can be described as an openness to see and observe scientific phenomena and objects, and an eagerness and willingness to ask questions and find out about things.

The most important and challenging question is then: How do we stimulate and develop kindergarten teachers' and kindergarten teacher students' scientific attitudes? According to perspectives in Vygotsky's cultural-historical theory, the best way to develop such competence should be for the teachers and teacher students to take part in scientific communities characterized by such qualities. Practices as observation, asking questions, planning how to find out of things, discussions, and argumentations should therefore be given high attention during trainee kindergarten teachers' science education. I have played down the importance of kindergarten teachers' scientific content knowledge. This does not mean that the focus and outcome of the exploration processes is unimportant.

Andersson & Gullberg (2014) suggest that kindergarten teachers should be given opportunities to reinforce and practice their pedagogical competence related to science practices. Based on process-oriented work with in-service kindergarten teachers, they identified four pedagogical content skills that teachers can benefit from when teaching science:

1. Paying attention to and using children's previous experiences.
2. Capturing unexpected things that happen at the moment they occur.

3. Asking questions that challenge the children and that stimulate further investigations.
4. Situated presence, that is, "remaining in the situation and listening to the children and their explanations" (Andersson & Gullberg, 2014, p. 294)

The researchers claim that highlighting such pedagogical skills and directing them towards scientific practices may divest teachers of feelings of inadequacy and poor self-confidence in relation to their ability to deliver science education in kindergartens.

9.8 Closing Remarks

Children's first encounter with science in kindergartens can lay a foundation for their later interest in science and development of scientific reasoning and thinking. These are skills of profound importance for future generations, both on a personal level, and as members of societies that must cope with global challenges that requires scientific reasoning and understanding. How kindergartens approach science education should therefore be discussed and examined closely. The aim of this chapter has been to contribute to this discussion.

The title *Kindergarten as a budding explorative scientific community,* points to my vision that children should be given opportunities to take part in kindergarten cultures dominated by openness to questions and eagerness to explore science related objects and phenomena. With Vygotsky's theory (1998) about how children learn and develop as foundation, I claim that if we want children to learn and develop scientific attitudes and skills, they have to experience and be part of a community in which such abilities are visible and prominent.

In implementing an approach to science education in kindergartens based on the practices of science, teachers' scientific attitude may be more important than their scientific conceptual knowledge. This should influence how we educate kindergarten teachers during their professional studies. Highlighting kindergarten teachers' pedagogical competencies and directing them to scientific practices as suggested by Andersson & Gullberg (2014) may be one way to go. I anticipate future discussions and research on how to develop communities characterized by scientific attitude and practices in both kindergarten and kindergarten teacher education.

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