Promoting young children’s scientific literacy as a dynamic practice

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Abstract

In this chapter, we draw on Green’s (1988) three-dimensional model of literacy and propose a framework for researching and enhancing children’s engagement and learning opportunities in science from a dynamic literacy perspective. The chapter shows how early science education that draws on multiliteracies pedagogy can provide children with rich opportunities to engage in operative, cultural and critical dimensions of scientific literacy embedded in children’s life-worlds. The chapter demonstrates how young children benefit from understanding how they can actively participate in the existing scientific culture as it occurs in children’s life-worlds. Regarding scientific literacy in the framework of dynamic literacy has the potential to offer cross-disciplinary viewpoints on science education.

Introduction

Contemporary society is strongly driven by science and technology. Not only are science and technology important for the innovation capability, prosperity and development of societies but also every citizen increasingly encounters science and technology in various forms in their daily lives all of which call for scientific literacy capabilities. For instance, we need to be able to evaluate the trustworthiness of the promises of food additives, make informed decisions whether to vaccinate children and build arguments why to change heating systems of houses from oil-based systems to geothermal heat.

To ensure citizens with agency and empowerment to participate in and make informed decisions on scientific texts and practices, there are a number of scholars that hold that the main aim for science education should be scientific literacy (ByBee & DeBoer, 1994; Millar, Osborne, & Nott, 1998). As Goodrum, Hackling, and Rennie (2001) emphasized, the purpose of science education is to develop scientific literacy and that this is a high priority for all citizens, helping them to be interested in and understand the world around them.

However, how scholars understand and promote scientific literacy is vague. Some interpretations stress the facts, concepts, and vocabulary of science, whereas other definitions highlight the scientific process and scientific thinking (Millar, 2006). In some definitions, the understanding of literacy with respect to science is narrowed to the ability to read and write scientific texts, talk about them, and memorize scientific vocabulary (Pearson, Moje, & Greenleaf, 2010). That challenge, however, is not prominent only within scientific literacy but in literacy in general (see also Marsh, Willet and Pandya in this issue). Contemporary education for scientific literacy is also criticized for its idea of locking science in laboratories: Students are pushed to act as professional scientists rather than offered possibilities to learn how to understand and implement scientific literacy in their own lives (Roth & Lee, 2002). However, to date, there is a lack of studies that understand the complexity and multimodal nature of literacy constituted of situated and transformed practice, with a critical framing (New London Group, 1996).

In this chapter, we draw on a case study that investigated young children’s scientific literacy as a dynamic literacy practice during a Poetry Science project implemented in a Finnish preschool. The
project was a part of MOI - The Joy of Learning Multiliteracies research and development program (see Introduction chapter). Thirty-one children aged 5 to 6 and their teachers participated in Poetry Science activities over a six-week period. The activities embraced the idea of playful, multimodal, and integrated approaches to scientific literacy. We analyzed the children’s scientific literacy practices through Green’s (1988) three-dimensional (3D) model of dynamic literacy. The key argument of this chapter is that scientific literacy can be positioned in the framework of multiliteracy and understood as a dynamic practice according to Green's 3D model. From that point of view, even young children can participate in the operational, cultural, and critical practices that enhance their capabilities in scientific literacy.

**Science for future scientists or science for all?**

Science education has been struggling for decades because it is generally seen as uninteresting and distant from everyday life, especially among young children (Potvin & Hasni, 2014). There have been debates concerning for whom we offer science education: for the people who strive for science- and technology-related careers or general-level science for everyone (DeBoer, 2000). Roberts (2007a) suggests that we can have two distinct visions on scientific literacy: vision I “looks inward at science itself – its products such as laws and theories, and its processes such as hypothesizing and experimenting” and vision II “looks outward at situations in which science has a role, such as decision-making about socioscientific issues”. However, it is highly problematic to set these visions into competitive positions because making science-related decisions require knowledge about the products of science. Recently, a vision III has been proposed that combines visions I and II and stresses the engagement in science including the viewpoints of dialogical emancipation, critical global citizenship, and socio-ecojustice (Sjöström & Eilks, 2017).

The exact definition of scientific literacy is not fully agreed (Sjöström & Eilks, 2017; Ng, 2012). This is problematic as scientific literacy is defined as the main goal for science education in many national core curricula from the early years on (Connor, 2007 in Ng, 2012). The concept of scientific literacy is missing from the Finnish National Core Curriculum for Early Childhood Education and pre-primary education (Finnish National Agency for Education, 2016). However, the idea that young children’s education provides them with possibilities to understand how science is present in everyday life and to practice skills needed to participate in scientific processes is emphasized as they are considered to enhance emerging understanding of concepts, practices making conclusions, and simple causal effects. In addition, the Finnish National Core Curriculum for ECE and pre-primary education stresses the aesthetic domains of nature and built environments, as well as development of positive attitudes toward nature.

**Scientific literacy**

In the research literature, there are presented multiple frameworks for scientific literacy (eg. Sjöström & Eilks, 2017, Ng, 2012) and next we will introduce the frameworks that are relevant in the context of this case study. Further, we blend these scientific literacy frameworks with theories of multiliteracies (NLG, 1996) and multimodality (Kress, 2009) and hence we argue that 3D model of dynamic literacies is potential to gain deeper understanding of early year's scientific literacy.

Shamos (1995) proposed a framework for scientific literacy that contains three dimensions. That hierarchical framework consists of *cultural*, *functional*, and *true scientific* literacy. The cultural level is the basic level of scientific literacy. A culturally literate individual has general knowledge of science, and he or she is capable of reading popular articles on science and following science-related debates in the media. Functional scientific literacy requires mastering scientific vocabulary
to be able to participate in conversations and to read and write coherently in meaningful contexts. For Shamos (1995), the “true level” of scientific literacy refers to high-level science habits of the mind as the ability to think creatively, logical reasoning, understanding of the role of experiments, and reliance on evidence.

Bybee (1997) suggested a framework for scientific literacy that has four dimensions: nominal, functional, conceptual and procedural, and multidimensional. The dimensions are hierarchical, and the nominal dimension is the lowest form of scientific literacy. This dimension refers to individuals’ ability to recognize a science-related concept, but their understanding is low. By functional dimension, Bybee means individuals’ ability to describe concepts by using a scientific vocabulary, however with a low understanding of it. Conceptual and procedural scientific literacy refers to individuals’ ability to develop some understanding of the conceptual schemes of science, procedural knowledge and skills, relationships between the parts of a science discipline, and the conceptual structure of the discipline. Multidimensional scientific literacy means that an individual understands the distinctions between science and other discipline areas, knows about the history and nature of science disciplines, and understands science in the social context. Similar to Shamos, Bybee argued that the highest level of scientific literacy is very rarely gained even among professional scientists.

Norris and Phillips (2003) enriches previously presented frameworks by bringing up the importance of individual’s values, independence and the role of wonder and curiosity that Bybee and Shamos do not stress. Norris and Phillips sum that scientific literacy has the following dimensions:
1. Knowledge of the substantive content of science and the ability to distinguish from non-science applications
2. Understanding science and its applications
3. Knowledge of what counts as science
4. Independence in learning science
5. Ability to think scientifically
6. Ability to use scientific knowledge in problem solving
7. Knowledge needed for intelligent participation in science-based issues
8. Understanding the nature of science, including its relationship with culture
9. Appreciation of and comfort with science, including its wonder and curiosity
10. Knowledge of the risks and benefits of science
11. Ability to think critically about science and to deal with scientific expertise.

The frameworks for scientific literacy pay attention to cognitive, epistemological, and affective dimensions of scientific literacy, but they rarely consider scientific literacy from theorizations of literacy practices (Norris & Phillips, 2003). The role of literacy is embedded in scientific inquiry practices as reading and writing about science. Evagorou and Osborne (2010) claimed that there are three main forms for using the language in the science context: talking, writing, and reading. This is problematic, since science is multimodal by nature as it holds several symbol systems and representations of knowledge which require high level understanding of the nature of scientific models and interpretation of various sets of symbols (Gilbert & Justi, 2009b). Further, researchers have found that young children engage in embodied practices when the children communicate about results and processes gained from inquiry activities (Stolpe, Frejd, & Wallner, 2015). If attention in science is monochromatically directed toward verbal expressions, many important messages from children’s meaning-making are lost. Whilst young children verbal expression are still developing they use other modes of communication to share their understanding of scientific concepts. Here the understanding scientific through multimodality becomes essential.

Although many scientific literacy frameworks rely on an individual’s cognitive development and epistemological viewpoints, Roth and Lee (2002) noted that scientific literacy is a collective praxis that evolves through conversations and participation in communities. Scientific literacy changes according to who, where, and how one participates in a collective conversation. The emphasis is
on how people participate in science-related conversations rather than paying attention to how people succeed in individualized tests of scientific literacy. This, in turn, points out that scientific literacy is not the property of an individual but an outcome of a socially constructed context-dependent practice. Roth and Lee’s view on scientific literacy can be understood as situated and transformative scientific literacy practice. Further, all scientific literacy frameworks underscore the critical dimension as ability to question and evaluate knowledge and scientific process is inherent in the nature of science. In this chapter, we understand scientific literacy as the ability to transform scientific knowledge and skills in one’s life, and to be an active and critical participant in society where science-related issues and discourses emerge. In addition, the multimodal nature of representations of science asks for understanding of multiliteracies and understanding of how we perceive and interpret science in various texts. Theory of multiliteracy brings together aspects from different scientific literacy frameworks and that notion we use to build a framework for understanding early years’ scientific literacy as a dynamic literacy practice.

**Building a framework for early years’ dynamic scientific literacy**

Multiliteracies underline literacy as situated and transformative practice with a critical framing (New London Group, 1996) that emerges in meaningful contexts that offer participants’ with multimodal opportunities for meaning making and communication (Kress, 2010). In this chapter, we argue that multiliteracy lenses can offer a useful framework for a new pedagogical philosophy to promote integrated scientific literacy in early childhood education. World is a complex system and to provide children with possibilities to build an understanding of it we can’t fence science but we need to introduce it within cultural and social contexts it naturally appear in young children lives. By this, we mean that science is not an isolated subject in it’s own silo but is embedded in children’s everyday lives. Next, we propose a framework for understanding and enhancing young children’s scientific literacy as a social practice through Green’s (1988) 3D model of dynamic literacy.

Drawing on Green’s (1988) 3D model, we understand that at least three dimensions are involved in multiliteracy practices: operational, cultural, and critical. The operational dimension refers to the skills that are needed to become a competent meaning-maker and communicator with abilities to use various modes and tools in different contexts. The cultural dimension focuses on understanding literacy as a cultural practice with its own rules, values, signs, and practices. The critical dimension refers to critical engagement with multimodal texts and communication, and being able to recognize the power relationships evident in all literacy practices. Green’s 3D model has been proved to be useful in different literacies, such as digital literacy (Marsh, 2016) and maker literacies (Marsh, Ahrnseth, & Kumpulainen, 2018).

In the context of scientific literacy, the operational dimension includes the skills required to become a competent meaning-maker. Thus, the operational dimension of scientific literacy refers to the skills needed to participate in the scientific process. These skills can be divided into two categories: basic science process skills and integrated science process skills. Basic skills are prerequisite for mastering the integrated science process skills. For young children it is important to practice basic level skills which are: making observations and interpreting them, measuring to make observations more accurate, classifying, making predictions and to communicate about these (Rezba, Sprague, McDonnough, and Matkins (2007).

**Cultural competence** in the context of science means understanding scientific inquiry as a social practice that includes understanding the cultural signs of science in the communication and meaning-making process. Science holds numerous sets of signs that are not generally used in everyday setting, for example symbols of chemical elements. Scientific knowledge is presented at least in three levels: a) macro level b) submicro level and c) symbolic level (Gilbert & Justi, 2009b).
and all those levels have distinct interpretive underpinnings. In macro level there are represented the real life experiences on phenomenon. eg. the solution is bubbling. In submicro level, there is represented through models the knowledge about what happens in non-visual molecular level. Symbolic level represents the phenomenon in the form of chemical reaction equation. Cultural competence has connections to the cultural level of scientific literacy of Shamos’s and Bybee’s nominal and functional dimensions. Both underscore the ability to recognize science-related texts and an ability to participate in them. Norris and Phillips (2003) listed under scientific literacy the ability to distinguish between science and non-science texts and to contribute in science-related conversations through cultural signs of science. The proper interaction skills and suitable communication approaches are essential to be a scientifically literate person (Holbrook & Rannikmae, 2009). The cultural dimension of scientific literacy includes science that occurs in people’s living cultures and social ecologies: scientific phenomena, science-related texts, and conversations. Further, it holds the shared enjoyment of science by appreciating the wonder and curiosity.

The critical dimension emphasizes the ability to engage in inquiry practice and critically evaluate all phases of inquiry from setting the questions to the conclusions. Critical dimension refers also to the critical attitudes towards scientific knowledge we meet through different media. There the understanding of how scientific knowledge is produced plays central role. The critical dimension of scientific knowledge is present in many frameworks of scientific literacy. Norris and Phillips argue for critical thinking to acknowledge the risks and benefits of science and for an ability to think critically about science. In children’s science processes, critical thinking can be observed through negotiating, asking clarifying questions, suggesting procedures, applying information to new situations, and analyzing causes (Ennis, 2013).

The Poetry Science project

Poetry Science is a novel approach to early science education to address young children’s need to participate in scientific literacy activities. It is situated in children’s culture and context, and they are constantly evolving, intersecting, hybrid, and transformative. The naturally curious child is at the center. The child-centerness and the agency of a child is highlighted through emphasizing imagination, dialogic meaning-making, cultural diversity, and integrated and emergent learning as guidelines. Inquiry approaches are widely recommended way to introduce science for children in all levels of education (Minner, Levy & Century, 2010). In inquiry approach, children are assumed to produce new knowledge, critically evaluate it and to transfer the knowledge into different texts to communicate the results.

Poetry Science activities (Vartiainen, 2017; Kumpulainen et al. 2018) entail theme-related poems embedded in rich and aesthetic visual designs which are considered to motivate children’s engagement in hands-on inquiry activities (Figure 1) (Caiman & Lundegård, 2018). As our view of scientific literacy is of an overarching, constantly evolving, and creative process, approaches to multiliteracy pedagogies and learning environments and materials benefit from the commitment to use multisensory, narrative, and playful ideas as guiding principles for pedagogical approaches. Engaging children in science processes is documented to benefit from approaches that harness storytelling and poems as starting points for hands-on activities (Kalogiannakis, Nirgianaki, & Papadakis, 2018; Mutonyi, 2016). The socio-material environment is collaborative and reshaping: Children are encouraged to interact with other children in ways they find meaningful. Physical space is used in various ways, and children are allowed to freely use floors, tables, chairs, and other physical objects for their inquiry processes.
Methods and design

The video and observation data were gathered at a Finnish preschool over a six-week period. Three groups of children (n=31) and their teachers participated in a Poetry Science activity once a week for 40 minutes at time. Video data were collected systematically throughout the project. There were three easily movable cameras located in the preschool classroom where the activities took place. Thus, although the children moved around the room, their actions and vocalizations were successfully recorded. Permission for gathering research data was obtained from the institution and from the children’s guardians. Permission was also obtained from the children, and they understood that they could refuse to be recorded at any time and that would not have an effect on their participation in Poetry Science activities. We paid careful attention to the children’s non-verbal signs to infer whether the children found filming and observing unpleasant.

The data were analyzed with lenses from the frameworks of multiliteracies (NLG, 1996) and multimodality (Kress, 2009) to better understand young children scientific literacy practices during inquiry activity. A meso-level analysis of the video data was conducted to recognize the episodes in which children engaged in scientific literacy practices. From these episodes, we chose representative excerpts for micro-level analysis. Young children’s ability to put their thoughts into language is still developing, and therefore, in the analysis, we underscored the notion that verbal language is just one mode of communication that is presented among other communicational modes (Norris, 2004).
Operational dimension: Like ocean foam

The children sat around two tables and worked in pairs with a science activity that was initiated with Penguin’s Balloon Puzzle card. Initiation happened in the start circle in which the poem was read to the children, and the group talked about the poem. The teacher used a finger puppet to facilitate the conversation. The aim for inquiry was set in the start circle so that children had an active role in suggesting the aims. Once the aim was set, the children moved to the tables where all the equipment was available. The children’s first task was an experiment involving the reaction of vinegar and baking soda. The children measured vinegar and baking soda inside a resealable plastic bag. “One,” Anna counts. “Two, we got two now.” She makes sure that Aaron is following the measuring. “Three.” She continues counting until there are five pipettes of vinegar.

After the children measured the soda and vinegar inside the bag, they closed it tightly. Once they closed the bag, they described to each other what they observed happening inside the bag. “Foam!” Anna shouts and moves the bag so that Aaron see it better. She giggles happily. “Foam!” Aaron repeats. He tries to touch the bag, but Anna moves it toward the other pair of children working at the same table.

The children’s observations were emotional, including happy whoops, laughing, and excited sighs. Scientific literacy includes the appreciation of and comfort with science, including its wonder and curiosity (Norris & Phillips, 2003). Among young children, joy and curiosity are constantly present. The children’s deep engagement in observation-making was evident by the children’s actions, gestures, and posture. They lean toward the bag to better see what is happening inside. They touch the bag and listen to it. The children spontaneously make observations through multiple senses. The ability to make observations is a fundamental science process skill, and all other process skills are dependent on this skill (Rezba et al., 2007). Individuals’ ability to develop some understanding of procedural knowledge and scientific literacy skills is central in Bybee’s framework but is not included in all frameworks. However, in young children’s inquiry practices, providing children with possibilities to engage in procedural practices is central: to make observations and use those observations for problem solving or conclusion making and through active participation.
(Byrne et al., 2016) to develop the basis of scientific thinking as described previously in this chapter (Norris & Phillips, 2003). Children used the labels for the reactants and equipment in this inquiry context. For young children, the operational dimension of scientific literacy includes the ability to address labels and concepts during the inquiry phases and communicate about the inquiry process.

The observation-making process blended with the connections that children draw on from their previous experiences which stem from their life-worlds. Aaron grabs the bag and squeezes it. “Wau.” He is attracted. Aaron holds the bag against his ear and listens carefully. Anna stretches her hand to take the bag. She gets it, listens it, too, and giggles. “Like ocean foam. This is cold. This is cold. This is cold!” She directs her description to the teacher nearby and the other children around the table. Anna describes her observation of the reaction of vinegar and baking soda as ocean foam. Holbrook and Rannikmae (2009) stress the relevance of science for everyday life. The relevance builds on understanding where science can be identified in different everyday contexts in children’s lives. The foam produced in the vinegar and baking soda reaction was also described as soap, a river, and lemonade. These words bring up children’s rich capacity to find contexts in which they have made similar observations at the macro-level of science. Here we can see where the operational domain of scientific literacy overlaps with the cultural domain in young children’s scientific literacy practices.

**Cultural dimension: Where did you attach the balloon?**

In *Penguin’s Balloon Puzzle*, the children’s task is to design a way to fill up balloons by using the observations and inferences they made with vinegar and baking soda. The next excerpt illustrates how Max and Jasmin participate in a problem-solving task. Jasmin and Max test several ways to fill up the balloon (Figure 2). Although many attempts failed, the children are very enthusiastic about trying out new solutions. Once in a while, they observe what kind of solutions others created. Jasmin and Max ask the other children questions: How much soda did you put in? Where did you attach the balloon? After each new idea, Max and Jasmin negotiate how to proceed. They laugh happily although another attempt failed again. Finally, they find a way to fill up the balloon.

Scientific literacy includes an ability to utilize appropriate evidence-based scientific knowledge and skills for problem-solving (Holbrook & Rannikmae, 2009). In this problem-solving task, children engaged in an activity in which correctness was evaluated with only the available evidence: the observations the children produced for the experiment at hand (Byrne et al., 2016). Gaining the correct answer is not the main point of young children’s cultural domain of scientific literacy as described in previous section; the main point is the creative process of planning, evaluating, revising, and searching for ideas from the cultural context that is present (Roth & Lee, 2002). Noticeable is that during the child-centered problem-solving task the children did not turn to teachers for help. Instead, the children observed and interviewed their peers to find a way to fill up the balloon. Through searching for ideas and new information from peers, the children created a context for meaning-making in which nobody was in the role of knowledge-holder; knowledge was created in the emergent problem-solving situation. This kind of cultural emphasis for co-creating scientific literacy has the potential to deepen children’s understanding of scientific literacy as a contribution in science-related texts and the nature of science as an evolving social construction of knowledge and skills (Norris & Phillips, 2003; Vygotsky, 1978).
Critical dimension: Let's do it backwards!

The children have been experimenting the reaction of vinegar and baking soda that is happening inside the plastic bag. They are enthusiastic about the reaction that made the plastic bag inflate, and they suggest ways to modify the experiment. Someone asks a question: What happens if we try to add vinegar and soda in the opposite way? The children get excited about the idea, and they propose ways to implement it. Henri has been washing the bag, and he returns to his partner Tim. Henri is very excited. He is skipping and running. “Tim, again!” he cheers. “Let’s do it backwards,” Tim suggests. Then Henri takes the lead and starts to instruct Tim: “You hold the bag. And remember, we do it backwards, baking soda first!” He holds his index finger up to show Tim the number of spoonfuls of baking soda to add. Henri looks at the teacher and non-verbally seeks for the teacher’s assurance for their self-initiated inquiry. Henri rubs his hands enthusiastically against his white lab coat. The teacher smiles and nods slightly. Henri is very eager: He giggles and encourages the other children to test the experiment backwards, too. Henri describes for a pair of girls who are working at the same table what the boys are planning to do. The girls want to try the opposite way as well. “Mila, let’s try it the opposite way,” Nelli suggests happily. The idea to modify the experiment spreads quickly from child to child, and finally, the whole group of children is testing the experiment so that they put the baking soda in the bag first and then the vinegar. They observe each other and negotiate who does what and in what way. They evaluate the process by comparing the results to results they got in the previous experiment, and they give instructions to the others: “Then you need to seal the bag” “I can measure it for you, like this.”

The previous excerpt gives an example of children’s critical participation in an inquiry activity. Here, the critical domain becomes noticeable through the children’s capability to provide new viewpoints on the experiment at hand. They engaged in the observation process in one situation, and they make a silent hypothesis about the situation in which the experiment has been modified slightly. The participation in the evaluation process happens in this case when the children give instructions to each other or they negotiate how to proceed. However, for example, in Henri’s short interaction with the teacher, it is evident that before the children try out their new idea to modify the experiment, they obtain permission from their teacher. Henri tells the teacher their intention, but it
can be inferred as an indirect question whether it is acceptable to proceed. The pedagogical approaches have a great influence on young children’s possibilities to participate in the critical process of scientific literacy. It benefits from learning environments that invite children to refine and modify science-related activities. The independence of learning science (Norris & Phillips, 2003) requires the courage to suggest and test new ideas. However, independence can be understood as independence from previously proposed models to participate in science practices and through a critical stance find new ways to produce scientific literacy and practices as a result of social participation in the emergent context of science (Roth & Lee, 2002).

Summary

The analysis of the dataset of this study showed that the children’s scientific literacy practices in different phases of inquiry can be mapped to operational, cultural, and critical domains of dynamic literacy. These practices are presented in Table 2 but are not the only ones. In different contexts, the practices will change and be elaborated, and new ways of participating will occur.

Table 2 Children’s scientific literacy practices

<table>
<thead>
<tr>
<th>Scientific literacy</th>
<th>Operational</th>
<th>Cultural</th>
<th>Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defining goals for the activity</strong></td>
<td>Children make questions and hypotheses</td>
<td>Children bring their previous experiences in their questions and the aim-generating process</td>
<td>Children challenge and/or question knowledge</td>
</tr>
<tr>
<td><strong>Observations and data collection</strong></td>
<td>Children describe observations</td>
<td>Children use scientific concepts</td>
<td>Children question observations and inferences</td>
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<td></td>
<td>Children measure</td>
<td></td>
<td>Children challenge the process</td>
</tr>
<tr>
<td><strong>Extension, elaboration, or revision of knowledge based on empirical data and observations</strong></td>
<td>Children make inferences and predictions</td>
<td>Children observe, imitate, and build on each other’s way of working</td>
<td>Children suggest extensions to or elaborations of the science activity and work collaboratively to test new ideas</td>
</tr>
<tr>
<td><strong>Communication about inquiry to others</strong></td>
<td>Children describe their methods for deriving their results, artefacts, or other outcomes</td>
<td>Children make connections between their everyday and scientific literacies (i.e., concepts and language)</td>
<td>Children evaluate how the results of their work can be applied across different situations and contexts</td>
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Discussion

In this chapter, we aimed to approach young children’s scientific literacy as a dynamic practice. The case study was grounded on the theories of multiliteracy, Green’s 3D model, and the frameworks of scientific literacy. Main result of this case study is that young children’s scientific literacy practices can be mapped through dimensions of dynamic literacy model and therefore, we suggest that young children benefit the pedagogical approaches in science that understand scientific literacy from the viewpoints of literacy frameworks. The children showed an ability to participate in science process skills, linking the topic of science-related conversation to their previous experiences and knowledge, adapting the results to the contexts that were familiar in the children’s culture, and suggesting elaborations and extensions for inquiry. Thus, scientific literacy goes beyond reading, writing, and talking in the context of science and reaches the levels of literacy where we understand the operational, cultural and critical characteristics of scientific literacy. Further, young children’s scientific literacy is situated and transformative practice and includes critical framing where relevant knowledge is co-created and transformed to address needs that emerge in a specific learning situation. If we understood scientific literacy as set of skills to produce, share, transform and evaluate the knowledge that is needed in emergent context we could get rid of the existing confrontation between the aims for science education. Whatever the situation is, it is simply impossible to teach all scientific knowledge that individuals come in need during their lives. Children would benefit most if they have the skills to handle various everyday science-related scenes with their scientific literacy practices as defined here.

Obviously pedagogical decisions, materials, people and learning environment guides children scientific literacy practices. When giving a chance, young children's science learning is situated and transformative practice as they are able to different roles during inquiry and transform the learned into new emerging context. Children asked for help and advice from other children and therefore created the culture where knowledge is scattered to the participants rather than focused only for one person, usually teacher. However, children at times carefully checked in verbal and nonverbal ways from a teacher whether the ideas were allowed to test during the inquiry process. There teacher has a great power to act as a promoter or as an inhibitor of a culture of scientific literacy where children’s independence is supported. Independence is valuable since it is needed to suggest new ideas (Norris & Phillips, 2003), which in turn, ultimately is learning.

By approaching science through child-centered pedagogies that highlight children’s agency and active role as the producers of new knowledge, we can empower children to understand themselves as active participants in socially constructed cultures of scientific literacy. In the discussions concerning the scientific literacy, the disconnection between science and culture has been noted as a concern. The divorce of science from humanities is seen as problematic because science strongly shapes our culture, and if science is introduced without a connection to cultural and societal dimensions, then decision-making is warped at the personal and societal levels. Providing young children with possibilities to act in multimodal and transformative learning environments that embrace rich social interaction, independency, and innovativeness can offer new possibilities to situate science in different cultural settings. Through that we might meet the aim to raise scientifically literate citizens who have a positive attitude toward science, understanding of the processes of science, and an ability to critically evaluate the science-related texts they meet in daily life (Ng, 2012; DeBoer, 2000; Shamos, 1995).

Further, we can understand that scientific literacy among young children is not a gradual development of individual cognitive capability but an endeavor of ways to participate in the existing culture of science-related texts and practices (see also Roth & Lee, 2002). As scholars have argued for decades, science education should be something that is useful for all. As we regard
scientific literacy among young children, they benefit from understanding how they can actively participate in the existing scientific culture as it occurs in children's life-worlds. Regarding scientific literacy in the framework of dynamic literacy has the potential to offer cross-disciplinary viewpoints on science education.

References


