Makerspaces, Multiliteracies and Early Science Education : The Finnish Approach

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Makerspaces, multiliteracies and early science education

The Finnish approach

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Abstract

This chapter discusses young children's makerspaces and making activities situated in Finnish Early Childhood Education (ECE) in connection to a national curriculum reform emphasising integrated multimodal, and playful Science, Technology, Engineering, Arts, and Mathematics (STEAM) learning. In specific, the chapter draws on a case study of a MakEY-related project that included 28 children aged 3–5 years old and their teachers in one ECE center making parachutes and skydivers with various tools and materials in the context of joint experimenting with and learning about air resistance. By drawing on the sociocultural theorizing and Green's (1988) 3D model of literacy, our work makes visible how children spontaneously connected their earlier experiences, multiliteracies and playful orientations to their maker activities while engaging in multimodal ways of making sense of their maker activity, including scientific literacies. Our work demonstrates how early science education, embedded in multimodal maker activities, offers educational potential for early science learning that connects with children's life-worlds, cultural practices and literacies, and personal interests. Playfulness, it is argued, should be considered a pivotal cross-cutting element of early science education and children's developing scientific literacy practices during maker activities and beyond.

Introduction

Young children are known to have a strong inner curiosity to explore the world around them (Eshach and Fried, 2005) and they regularly display an interest in science-related phenomena (Baram-Tsabari, Sethi, Bry and Yarden, 2006). The most commonly identified challenge of formal science education is, however, its inability to create a connection with young people's natural curiosity in science as it is experienced in their everyday lives. Therefore, children and youth often find formal science education disconnected from their experiences, literacies and life-worlds (Krapp and Prenzel, 2011; Osborne, Simon and Collins, 2003; Potvin and Hasni, 2014). As a result, researchers in Finland and around the world have emphasised the importance of creating science education that draws on children's everyday lives, literacies and

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cultures. This includes cultivating approaches to science education that are playful and hands-on and in which the context arises from children's everyday experiences and life in general (Bulunuz, 2013; Kumpulainen et al., 2018a). Also, integrating play into enquiry-based science activities has been reported to enhance children's meaning-making capabilities in science (Akman and Özgül, 2015).

Recently, makerspaces have aroused some interest in Finnish science education, and internationally, as a potential means of creating meaningful and transformative connections between children's everyday and scientific literacies (Kajamaa and Kumpulainen, in press; Kumpulainen, 2017). Maker activities have also been reported to enhance peer collaboration while diminishing more traditional teacher–child relationships and roles (Kumpulainen, Kajamaa and Rajala, 2018; Vossoughi and Bevan, 2014). In educational makerspaces, scientific literacies are typically embedded in an integrated science, technology, engineering, arts and mathematics (STEAM) curriculum with hands-on creative activities, offering children different opportunities to engage in the learning of science and other important 21st-century skills, such as problem-solving, critical and creative thinking, collaboration and communication (e.g. Halverson and Sheridan, 2014; Litts, 2015; Marsh et al., 2017; Stornaiuolo and Nichols, 2018). Furthermore, makerspaces can, reportedly, have a positive effect on youth's interest in science, enhancing feelings of competence and a willingness to engage in science (Krishnamurthi, Bevan, Rinehart and Coulon, 2013).

While less is known about the educational potential of makerspaces in early childhood education (ECE) (Marsh et al., 2017), emerging research suggests that makerspaces can contribute to children's creative and innovative practice (Wohlwend, Scott, Yi, Deliman and Kargin, 2018). Maker activities are characterised by opening up a creative space conducive to STEAM learning in which children can collaboratively design, plan, reuse, test and refine artefacts for their own and/or collective purposes (Halverson and Sheridan, 2014). Maker activities call for alternative skillsets, knowledge and literacies compared to more traditionally controlled science experiments (Vanderhoof, in press). Yet, very little is currently known about the ways in which children relate to and make sense of scientific literacies during their maker activities in ECE, and how these interact with their earlier experiences and everyday literacies. Furthermore, there is a lack of research and overall understanding of the significance of playfulness in young children's maker activities for the enhancement of their scientific literacies and science learning.

Motivated by these gaps in current research knowledge, this chapter discusses a maker project in Finnish ECE in connection with a national curriculum reform emphasising integrated multimodal and playful STEAM learning activities in early years and primary education (Kumpulainen et al., 2018b). The maker project entailed children making parachutes and skydivers with various tools and materials, and then experimenting with and learning about air resistance with the artefacts they had created.

The maker project discussed in this chapter draws on work undertaken in an international, EU Commission-funded project: 'Makerspaces in the early years: Enhancing digital literacy and creativity' (MakEY). In Finland, the MakEY project interacts with an ongoing national research and development programme, *The Joy of Learning Multiliteracies (MOI)*, launched by the Finnish Ministry of Education and Culture, which develops new pedagogies, learning environments and materials in accordance with the new core curriculum for early childhood, pre-primary and early primary education (Kumpulainen, 2019 ; Kumpulainen et al., 2018b). In response to the aims of MakEY, the maker project discussed in this chapter responds to the need to explore the potential role and value that makerspaces can have in the early childhood curriculum, with a specific focus on early science education.

Drawing on sociocultural theorising and Green's (1988) 3D model of literacy, our chapter demonstrates how children spontaneously connect their earlier experiences and playful orientations to their maker activities, while engaging in and making sense of their maker activity, including scientific literacies. In this chapter, we draw specific attention to the nature of children's meaning-making during their maker activity at the intersection of the operational, cultural and critical dimensions of literacy. Our work points out how children 'playing with science' creates a pivotal intersecting space for their engagement in scientific literacy practices in the context of making. Our work also underscores the importance of multimodal analysis in tracing the nuanced ways in which children make meaning and learn within maker activities.

Unpacking children's meaning-making through sociocultural lenses

Acknowledging the socioculturally situated, playful and imaginative elements of children's meaning-making creates the conceptual basis for our investigation of children's maker activities. We hold that focusing on the creative and playful dimensions of children's maker activities can lead to novel investigations and insights where cognition, affect and bodily activity can be examined in unison (Roth and Jornet, 2016). We also hold that meaning-making, thought, emotion, play and creativity, as well as the creation of relationships, are an integrated whole. When any of these aspects are left out or broken apart, children's learning and development are hindered (Connery, John-Steiner, and Marjanovic-Shane, 2010; Vygotsky, 1978).

In his genetic law of development, Vygotsky (1978) emphasised the primary role of social interaction for human learning and development and proposed that the process of a child's cultural development occurs in two phases: first on the social plane and then on the intra-psychological plane. For sociocultural theorising, an essential feature of learning is that it creates a zone of proximal development; learning awakens a variety of internal developmental processes that can only operate when a child is interacting with other people in their environment. Once these interactional processes are internalised, they become part of the child's independent developmental achievement (Vygotsky, 1978).

Sociocultural theorising also maintains that play is one expression of meaning-making that occurs across one's lifespan. Meaning-making, on the other hand, is the construction of knowledge to reach an understanding with other people within and across a variety of situations and modes (Vygotsky, 1986). For Vygotsky, play represents a social form of embodied imagination, leading to complex symbolic constructions, behavioural mastery, collaborative protocols, emotional arousal and control, and the production of group cultural lore (Vygotsky, 1976). In early childhood, play emerges as the growing child's motives shift towards the realisation of personal desires. Because these desires are not available in reality, the child seeks to realise them through imagination. Play, therefore, represents the seeds of imagination in development, or imagination in action (Connery, John-Steiner and Marjanovic-Shane, 2010).

Vygotsky underscored two characteristics in play: the creation of imaginary situations and rules. He discovered that children are able to follow rules in play before they can adhere to those in other real-life situations. Play for Vygotsky represents one form of the zone of proximal development (ZPD); action in the imaginative sphere, the creation of voluntary intentions and the formation of real-life plans and volitional motives all appear in play and thus make it the highest level of early years development (Vygotsky, 1976). Taking all this together, a sociocultural viewpoint provides a fruitful lens for understanding children's maker activities with worthwhile insights into understanding play, imagination and meaning-making.

Scientific literacy from the perspective of a 3D model of literacy

Drawing on Green's (1988) 3D model, our work holds that there are at least three dimensions involved in children's scientific literacy practices: i) operational, ii) cultural and iii) critical (see also Marsh, 2016; Marsh, Arnseth and Kumpulainen, 2018). In our work, we are interested in applying and further developing the 3D model of literacy to help understand scientific literacy as it evolves in a child's maker activities.

Operational elements include those skills that are needed to become a competent meaning maker and communicator, with the ability to use various modes and tools in different contexts. In the context of science and scientific literacy, the operational dimension includes being able to engage in scientific process, such as making observations and inferences, and using various scientific tools for experimentation, including measurement tools.

The cultural dimension focuses on understanding scientific literacy as a cultural practice with its own rules, values, signs and practices (see also Snow and Dibner, 2016). In addition, 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.

The critical dimension refers to critical engagement with science-related texts and communication, as well as being able to recognise those power relationships that are evident in all literacy practices. For instance, the ability to ask questions about scientific processes, and to question the results, is a vital critical thinking skill in the context of scientific literacy and understanding the intentions behind different kinds of communication and texts. Table 4.1 demonstrates how these three dimensions of literacy relate to children's scientific enquiry during their maker activities, as identified in our research work (see Vartiainen and Kumpulainen, in press). It is worth noting that these practices are not restricted to those presented in the table, as they will change and evolve, and new ways of participation will arise in different contexts.

Table 4.1 Children's scientific literacy practices in their maker activity

Scientific literacy	**Operational**	**Cultural**	**Critical**
Defining goals for an activity	Children form questions and hypotheses	Children bring their former experiences into their questions and aim-generation process Children use scientific concepts	Children challenge and/or question knowledge

Observation and data collection	Children describe and record observations Children measure	Children use scientific language, i.e. concepts and labels Children describe observations by comparing them to examples from everyday life	Children question observations and inferences
Extension, elaboration or revision of knowledge based on empirical data and observation	Children make inferences and predictions	Children suggest extensions or elaborations to science activity and work collaboratively to test new ideas Children observe, imitate and build on each other's ways of working	Children use previous observations to test their hypotheses, extensions and/or elaborations Children challenge and correct each other's inferences
Communication about enquiry to others	Children describe their methods for deriving their results, artefacts or other outcomes	Children make connections between their everyday and scientific literacies (i.e. concepts and language)	Children evaluate how the results of their work can be applied across different situations and contexts

Introduction to the Poetry Science maker project

The maker project discussed in this chapter took place in a Finnish ECE centre and included 28 children aged 3–5 years old and their teachers. The maker project was embedded in the recently introduced national ECE curriculum framework, which emphasises integrated, multimodal and playful STEAM learning activities. The conceptual dimension of the maker project was built around those chemical and physical phenomena that are directly observable in children's everyday lives, in this case, air resistance.

The maker project is deeply rooted in Finnish ECE and the latest curriculum reform. Its pedagogical principles encourage children to use their imagination, creativity and collaboration, the cornerstones of the Finnish ECE and of the maker philosophy in general. Finnish policy maintains that ECE should promote pedagogy that includes multimodal, multi-sensory and playful characteristics. Children are encouraged to explore, use and produce meanings in different environments, using different tools in and across activities and contexts. Opportunities for experimenting, making and producing, both individually and collaboratively, are valued, as these situations are recognised as promoting creative thinking, teamwork skills and literacy skills in children (Finnish National Agency for Education, 2016). Play, curiosity and imagination are central pedagogical principles in the operational culture of Finnish ECE, recognising play as a vital source of children's holistic development.

The children's ideas for their maker activity were fed through the Poetry Science approach (Vartiainen, 2017), developed as part of the Joy of Learning Multiliteracies (MOI) research and development programme (Kumpulainen et al., 2018b). Poetry Science Cards entail theme-related poems embedded with rich, aesthetic visual designs that motivate children to explore and make meaning from familiar scientific phenomena, such as flying. Engaging children in science processes is known to be beneficial when using approaches that harness fairy tales and poems as starting points for hands-on activities (Feasey, 2006; Kalogiannakis, Nirgianaki and Papadakis, 2018; Mutonyi, 2016). The Poetry Science approach also resonates with the 'maker philosophy', in that it embraces creativity and innovation through the design and construction of physical objects. Here, maker activities were enriched with both playfulness and whimsical characteristics of inventiveness, e.g. inventing ways in which fish could fly to a tree (Bevan, Gutwill, Petrich and Wilkinson, 2015). The pedagogical principles behind Poetry Science include shared story-reading and -telling that help children recall their previous experiences for joint interaction. Children's creativity plays a role in all phases of maker activity, from storytelling, to design, making and playing with artefacts. The socio-material environment of the maker project is collaborative and transformative; children can 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 meaning-making processes.

The actual poem the children were introduced to at the beginning of the maker project was about two fish who wanted to fly to a tree and make a nest there. The fish made a plan. However, in the end, they realised that fish cannot fly (Figure 4.1).

Figure 4.1 'Flying Fish' Poetry Science Card

After listening to and engaging with the poem, the children were encouraged to imagine what would happen if fish could fly to a tree. The children were invited to invent and suggest different ways in which fish could reach the tree: someone could lift them, they could use a helicopter or a hot-air balloon, or they could build an escalator. Allowing children to toy with impossibility at the beginning of maker activity sets a playful tone for the entire project.

Next, the children proceeded to design and make parachutes and skydivers with various tools and materials, including newspapers, string and playdough, and then experiment with and learn about air resistance via their self-made artefacts. The children had an active role in designing and making their parachutes – or whatever else the children imagined them to be. Once the parachutes were ready, the children tested how they worked, spreading around the ECE space. The children's making was supported by the teachers according to each child's needs.

Methods

The data collection included observation, video-recording and collecting children's artefacts over the whole maker project. Prior institutional and parental permission was granted for the children's involvement in the research. We also asked all participants, teachers and children, for their permission to record them working, and it was clarified that the opportunity to take part in the maker project was not dependent on their participation in the research. The children were told that they could ask us to stop filming or making notes at any point, and we were sensitive to non-verbal signs suggesting they would rather not be observed.

The analysis of video data, amplified by observational field notes, was grounded in a social semiotic framework (Bezemer and Kress, 2016), and the analysis process utilised characteristics of multimodal analysis methods (Norris, 2004). For the purposes of this chapter, we have chosen two representative situations from the whole data set to illuminate the children's maker activity, with a specific interest in the role of play and imagination in their making meaning of scientific literacies.

Children's meaning-making during maker activities

Vignette 1: Imagination as a fuel for meaning-making

> A group of children sit or lie comfortably on a floor in a circle. They have just engaged with a poem about two fish that want to fly, read aloud by their teacher. In the preceding conversation with the teacher and each other, they have agreed that fish cannot fly, but birds can. 'Fish would need wings!' a child shouts cheerfully. 'Yes, wings,' a few children echo. 'Are there some other things the fish could use for flying?' a teacher wonders. The children look thoughtful. 'With the wings of flying fish,' a child ponders. 'And something else…' the teacher encourages. 'Air–' one child starts to vocalise his idea, '–plane,' another child joins in. 'A rocket,' someone shouts. 'And a helicopter!' a boy adds. 'I have been on a plane,' a girl says. 'Me too, it was fun! We went on a holiday.' Children speak enthusiastically over each other. A quiet moment occurs while the children think of other options. A boy whispers: 'A rocket can fly to the moon.' Playing with the idea of fish that can fly, the teacher continues: 'Let's imagine that the fish were able to manage to go to the tree. How could they come down in a safe way?' The teacher drums up the children's imagination. 'With a parachute,' a child suggests. 'Yes, a parachute,' other children approve the idea. 'The birds can dive,' a girl ventures. 'The fish can use an umbrella,' a boy suggests happily. Another boy is still thinking about the idea of diving birds: '…and they snatch a fish after diving,' he explains. 'Yes, that's the way it goes,' confirms the girl who initiated the talk about diving birds. 'I have seen it on my dad's smartphone,' she continues.

The children's conversation was meandering but at the same time built on each other's contributions. The poem invited the children to share their cultural experiences, memories and knowledge gained from their everyday lives, like flying in a plane on holiday. The children also related the poem to their earlier knowledge about flying objects, e.g. when a boy whispered that a rocket can fly to the moon. Obviously, the boy did not have direct experience of rockets, but this experience had nevertheless been mediated through some media, allowing the boy to build a knowledge structure about flying rockets. As Vygotsky argues, imagination is not the inner characteristics of young children; instead, it is built on children's prior experiences. Hence, children's imaginative mental actions are constructed based on connections to their earlier experiences and life-worlds. By drawing on previous experience and knowledge, the children created a social context for their joint meaning-making of flying and air resistance. By using their imagination, they showed skills in inferring from the poem and producing their own meanings for the events in the poem. Making inferences by using previous observations is one key skill related to the scientific process and is therefore connected to the operational dimension of scientific literacy (Vartiainen and Kumpulainen, in press). The poem engaged the children in conversation enriched with imagination. It encouraged them to ponder and play with different possibilities. Creating these spaces for children's imagination, in the context of science, has been reported to significantly enhance children's engagement in science-related, problem-solving activities (Caiman and Lundegård, 2018).

A noticeable dimension of the children's poem-enhanced conversation about fish that wanted to fly to the tree was a shared commitment to imagination. The children agreed to pretend that it was possible for the fish to fly to the tree, despite the fact that they realised it would be impossible in the real world. Hence, they created a new emergent context for learning (Serafini and Gee, 2017), in which science and imagination combined in the process of playful meaning-making. This playful mental space offered the children possibilities to participate in the cultural and critical dimensions of dynamic literacies. For Vygotsky, imagination 'becomes the means by which a person's experience is broadened because he can imagine what he has not seen, can conceptualise something from another person's narration and description of what he himself has never directly experienced' (Vygotsky, 2004, pp. 17). Together, the children extended the context of the poem through their collective imaginative activity (see also Caiman and Lundegård, 2018). Here, it was evident that imagination is a process (Dewey, 1980) that is affected by social interaction. The children needed to use their imagination to visualise other children's narratives about flying. Through imaginative activities, children could build on others' ideas and thus co-create the meaning of flying.

Vignette 2: Imaginative play as meaning-making

A group of three boys – Eemil, Alex and Joonas – have finished their parachutes. The boys are observing the parachutes in different locations. The teacher helps Joonas make observations by assisting him in dropping the parachute and draws his attention to how it floats. In the meantime, Alex's parachute strings get knotted up and he lays the parachute down on the chair. He picks up the parachute from the playdough skydiver. The parachute is hanging upside down while Alex comes to observe what Eemil is doing with the teacher. The teacher helps Alex get the strings straight, and they drop the parachute several times together. Joonas has observed the other boys' actions, and he turns his parachute upside down. He swings it carefully from side to side. He tries to catch Eemil's attention by swinging the parachute near Eemil's face. Eemil smiles and turns his parachute upside down, following Joonas's example. He starts swinging the parachute from side to side; meanwhile, he is carefully looking at the parachute. Eemil makes bigger swings and he spins around with the parachute so that the parachute arcs in a circular movement and fills up with air (Figure 4.2).

Figure 4.2 Eemil is swinging and spinning his parachute

Meanwhile, Alex observes his parachute, which is upside down. He makes a pumping vertical movement. That causes the parachute to change its shape accordingly. He walks to Eemil and says, 'Look at this,' and he shows the pumping movement. Eemil repeats the pumping movement and lets his parachute fall. He laughs out loud when the parachute quickly falls down. Alex joins in. He drops his parachute several times, and after that, he goes to the teacher and shows his observation. Alex drops the parachute upside down and picks it up. He starts swinging it and adds a buzzing sound. He sprints to the other side of the room and makes a car-like sound. The parachute follows in a vertical movement behind him. He runs again but quickly stops and observes how the parachute is affected by the movement change. Next, he runs but dives to the floor to see how the parachute behaves. Joonas and Eemil join Alex. They start making an engine sound and whirling their parachutes. They spin around and make pumping movements. A boy, Niki, who has been experimenting with his parachute elsewhere, joins the three boys. Niki looks for a moment at what the other boys are doing, and then he joins them by starting the same spinning and pumping activity with his parachute (Figure 4.3).

Figure 4.3 Niki spins the parachute

All four boys run to the next room. Then they run back. Eemil starts to run around the table while making his parachute fly. His parachute makes some wild spins in the air. Joonas walks round the table. He holds his parachute in front of him to see how it moves. Niki's parachute flies wildly in the air and spins many times (Figure 4.4).

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Figure 4.4 Eemil and Niki are participating in imaginative play with parachutes. Eemil is making a pumping movement and Niki is spinning his parachute around.

> Eemil and Niki run in a small circle and then continue running round the table while shouting: ‘Bang, bang!’ Joonas stops running and sways his parachute slowly in the air. He repeats, ‘Bang, bang.’ Eemil says, ‘This is spraying water.’ Niki sways his parachute in the air and repeats after Eemil, ‘Water.’ Niki slams his parachute on the floor and says, ‘I’m falling.’ Then he continues running round the table, holding his parachute in his hand.

The previous vignette describes a moment from the latter part of the maker project. Here, the children have made their parachutes and have free time, no rush, to experiment with their parachutes. In this example, we can see a shift where the children’s observations about the parachute and its properties turn into imaginative play. Making observations is one key skill needed to engage in science processes and to experiment. Thus, it is one of the operational domains in scientific literacy practices. The children made observations at the beginning of the vignette, seemingly independently of one another but, in fact, they were observing carefully what other children did. The children repeated the observation processes that others had engaged in. When the children started a shared play with the parachutes, they elaborated on the meanings they had been addressing for air resistance while observing the parachutes. The play constructed a micro learning environment wherein the children tested and elaborated their meanings of air resistance (Nicolopoulou, 1993). With respect to meaning-making processes, it is important that children are provided with opportunities to draw conclusions as a result of their active engagement. Hands-on activities that stimulate the imagination allow children to be active both mentally and physically.

In this vignette, the children's conclusions about air resistance formed a core part of how parachutes acted within the play. For Vygotsky (1978), the foundation of play is built on children's desires that cannot be met in the moment. Hence, to fulfil their motives, children invent imaginary situations, i.e. play activity, to meet their needs. Vygotsky also argued that children's play, although imaginary, is mediated by rule-based behaviour embedded in their everyday lives. Play therefore requires children to abstract and transfer the meaning of their real-life practice to their imagined scenario in the play activity. For Vygotsky, such abstraction from concrete to imaginary requires children's use of a pivot – an action or object that carries meaning from real life to imaginary play activity. In using such pivots, children begin to exert self-control by regulating their own activity according to the rules of their imaginary play. Parachutes were the bridges that allowed the children to move back and forth between concrete observations and imaginative play, which settled the children's conclusions into the context of their cultural experiences.

The children were able to adopt and use their newly constructed meanings for air resistance into their play activity. They did not vocalise their conclusions, but they did use them as part of their imaginative play. Imagination is thought to be at the core of the cultural development of a child, originating within social interaction and the cultural-historical moment of a child's development. Children's imaginative play can offer an important window into understanding children's science-related, meaning-making processes. Since science requires particular expressions, labels and words that are not used in everyday language (Evagorou and Osborne 2010), it is challenging for young children to put their conclusions into words. Play, then, can be used as a channel to communicate conclusions and place them in a wider context that stems from children's life-worlds.

Conclusions

In this chapter, we have shed light on children's meaning-making during maker activity in the context of playful, story-like and hands-on STEAM activities situated in Finnish ECE. Following the philosophy of making and the novel curriculum requirements set by the Finnish Agency of Education, children's agency and active participation were emphasised (Johnson, Adams Becker, Estrada and Freeman, 2015). The maker project allowed children to collaborate and interact in multimodal and playful ways, using space and artefacts in creative ways.

This case study points out that children's meaning-making about air resistance happened through a maker project by playing with objects – parachutes – they had made and sharing this play with other children. Through this playful meaning-making, the children not only participated in the process of science but also connected a scientific phenomenon to their own culture and experience by playing with it. As Elkonin (2005) argues, play is a key activity through which children gain skills, knowledge and understanding. With this in mind, we suggest that there is potential to widen the view of play in the early years of science activities beyond enquiry-based science instruction by viewing science through theories of literacy as a dynamic practice (Green, 1988).

This study widens the view of playfulness in science education within the context of maker education to include the idea of 'playing with science'. Playfulness and connecting science to stories and picture books have been found to enhance children's knowledge about scientific phenomena and support their positive experiences of learning about science (Kalogiannakis, Nirgianaki and Papadakis, 2018; Mutonyi, 2016). Young children make meanings by interacting with objects and phenomena, testing what it is possible to do with them and how they react to different manipulations.

Green's (1988) 3D model of literacy, amplified by a multimodal analysis, allowed us to assess children's meaning-making in science during their maker activities. In the making activity, it was observed that the children engaged in the operational dimension of scientific literacies by making observations, inferring and making predictions. They connected air resistance to their previous experiences of the phenomenon. The children also engaged in the critical dimension by evaluating and suggesting different viewpoints on flying, plunging and hovering. With regard to the key dimensions of operational, cultural and critical scientific literacy, the children engaged in a process that we call 'playful meaning-making' (Figure 4.5). We define this as a multimodal activity that stems from children's self-motivated inspiration to play with artefacts they have made. From the vignettes presented in this study, we can identify the children's processes of engaging in play for meaning-making in the context of science.

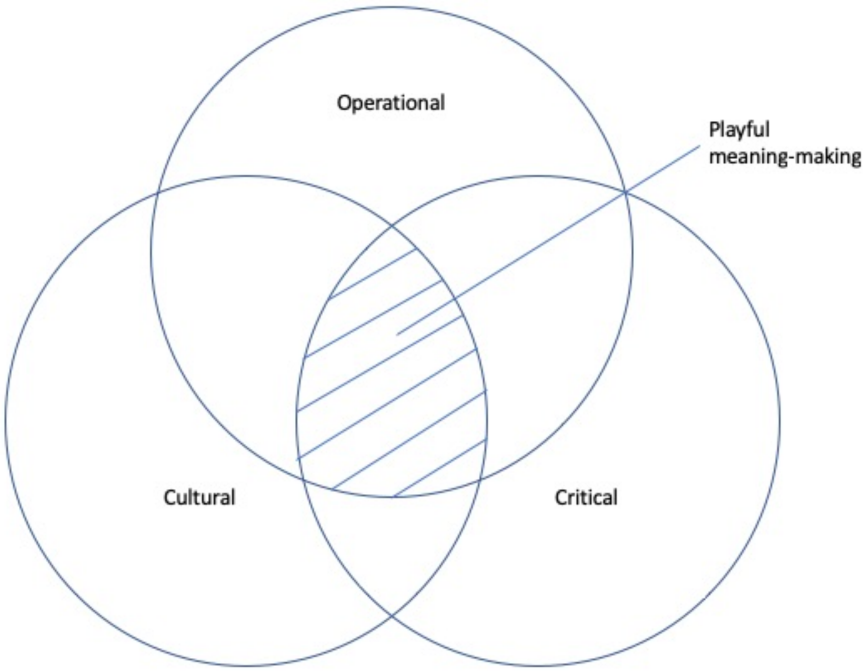

Figure 4.5 Position of play within children's cultural, operational and critical scientific literacy practices

This study highlights children's social, cultural and playful processes while they are participating in maker activities. Playful maker-oriented science activities offer child-centred approaches, providing children with opportunities to translate science into their culture and life-worlds and, through that, to use available tools and materials to construct meanings. Connecting the philosophy of making to imaginative and playful approaches underscores children's agency and active participation, as well as their self-initiated play with artefacts. Playful meaning-making brings together the skills that multiliterate individuals need: the abilities to produce texts, infer, refine and critically evaluate them, and enrich these processes with imagination. The children's shared process of making and playing with parachutes in their maker activity provided them with an opportunity to make meanings about air resistance. Here, the children's everyday literacies and practices intersected with scientific literacies. It was in these hybrid interactions that the children co-created meanings via play. We hold that such a playful approach to early science education can lead to learning and relationships that stick and foster children's personal curiosity and interest in science.

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References

Akman, B. & Özgül, S. G. (2015). Role of play in teaching science in the early childhood years. In K. Trundle & M. Saçkes (eds), *Research in early childhood science education* (pp. 237–258). Dordrecht, the Netherlands: Springer.

Baram-Tsabari, A., Sethi, R. J., Bry, L. & Yarden, A. (2006). Using questions sent to an Ask-A-Scientist site to identify children's interests in science. *Science Education*, 90(6): 1050–1072.

Bevan, B., Gutwill, J. P., Petrich, M. & Wilkinson, K. (2015). Learning through stem-rich tinkering: Findings from a jointly negotiated research project taken up in practice. *Science Education*, 99(1): 98–120.

Bezemer, J. & Kress, G. (2016). *Multimodality, learning and communication: A social semiotic frame*. London: Routledge.

Bulunuz, M. (2013). Teaching science through play in kindergarten: Does integrated play and science instruction build understanding? *European Early Childhood Education Research Journal*, 21(2): 226–249.

Caiman, C. & Lundegård, I. (2018). Young children's imagination in science education and education for sustainability. *Cultural Studies of Science Education*, 13(3): 687–705.

Connery, M. C., John-Steiner, V. & Marjanovic-Shane, A. (eds). (2010). *Vygotsky and creativity: A cultural-historical approach to play, meaning making, and the arts*. Vol. 5. New York, NY: Peter Lang.

Dewey, J. (1980). *Art as experience*. 2nd ed. New York, NY: G. P. Putnam's Sons.

Elkonin, D. B. (2005) The psychology of play. *Journal of Russian & East European Psychology*, 43(1): 11–21.

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

Evagorou, M. & Osborne, J. (2010). The role of language in the learning and teaching of science. In J. Osborne & J. Dillon (eds), *Good practice in science teaching* (pp. 135–157). Maidenhead, England: Open University Press.

Feasey, R. (2006). Using stories and poems in science primary. *Science Review*, 92: 8–10.

Finnish National Agency for Education. (2016). *National Core Curriculum for Early Childhood Education and Care*. Retrieved from:https://www.oph.fi/fi/koulutus-ja-tutkinnot/varhaiskasvatussuunnitelmien-perusteet, 29 October 2018.

Green, B. (1988). Subject-specific literacy and school learning: A focus on writing. *Australian Journal of Education*, 32(2): 156–179.

Halverson, E. R. & Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review*, 84(4): 495–504.

Johnson, L., Adams Becker, S., Estrada, V. & Freeman, A. (2015*). NMC Horizon report: 2015 K-12 edition*. Austin, TX: The New Media Consortium.

Kajamaa, A. & Kumpulainen, K. (in press). Digital learning environment mediating students' funds of knowledge and knowledge creation. *Studia Pedagogia*, 23(4).

Kalogiannakis, M., Nirgianaki, G. M. & Papadakis, S. (2018). Teaching magnetism to preschool children: The effectiveness of picture story reading. *Early Childhood Education Journal*, 46(5): 535–546.

Krapp, A. & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, 33(1): 27–50.

Krishnamurthi, A., Bevan, B., Rinehart, J. & Coulon, V. (2013). What after-school STEM does best: How stakeholders describe youth learning outcomes. *After-school Matters*, 18: 42–49.

Kumpulainen, K. (2017). Makerspaces: Why they are important for digital literacy education. In J. Marsh, et al. (eds), *Makerspaces in the early years: A literature review* (pp. 12–16). Sheffield: University of Sheffield, Makey Project. Retrieved from: http://makeyproject.eu/wp-content/uploads/2017/02/Makey_Literature_Review.pdf

Kumpulainen, K. (2019). Promoting the Joy of Learning Multiliteracies from early years onwards: An educational reform initiative in Finland. *Media Education Research Journal*, *8*(2): 83 – 94.

Kumpulainen, K., Kajamaa, A. & Rajala, A. (2018a). Understanding educational change: Agency-structure dynamics in a novel design and making environment. *Digital Education Review*, 33: 26–38.

Kumpulainen, K., Sintonen, S., Vartiainen, J., Sairanen, H., Nordström, A., Byman, J. & Renlund, J. (2018b). *Playful parts: The joy of learning multiliteracies*. Helsinki: Kiriprintti Oy.

Litts, B. K. (2015). Making learning: Makerspaces as learning environments. Unpublished doctoral dissertation. University of Wisconsin, Madison, Wisconsin, US.

Marsh, J. A. (2016). The digital literacy skills and competences of children of pre-school age. *Media Education: Studi, Ricerche, Buone Practice*, 7(2): 197–214.

Marsh, J., Kumpulainen, K., Nisha, B., Velicu, A., Blum-Ross, A., Hyatt, D., Jónsdóttir, S. R., Levy, R., Little, S., Marusteru, G., Ólafsdóttir, M. E., Sandvik, K., Scott, F., Thestrup, K., Arnseth, H. C., Dýrfjörð, K., Jornet, A., Kjartansdóttir, S. H., Pahl, K., Pétursdóttir, S. and Thorsteinsson, G. (2017) *Makerspaces in the early years: A literature review*. Sheffield: University of Sheffield, MakEY Project.

Marsh, J., Arnseth, H. & Kumpulainen, K. (2018). Maker literacies and maker citizenship in the MakEY (Makerspaces in the Early Years) Project. *Multimodal Technologies and Interaction*, 2(3): 50.

Mutonyi, H. (2016). Stories, proverbs, and anecdotes as scaffolds for learning science concepts. *Journal of Research in Science Teaching*, 53(6): 943–971.

Nicolopoulou, A. (1993). Play, cognitive development, and the social world: Piaget, Vygotsky and beyond. *Human Development*, 36(1): 1–23.

Norris, S. (2004). *Analyzing multimodal interaction: A methodological framework*. London: Routledge.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9): 1049–1079.

Potvin, P. & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. *Studies in Science Education*, 50(1): 85–129.

Roth, W.-M. & Jornet, A. (2016). Perezhivanie in the light of the later Vygotsky's Spinozist turn. *Mind, Culture and Activity*, 23: 315–324.

Serafini, F. & Gee, E. (eds). (2017). *Remixing multiliteracies: Theory and practice from New London to new times*. New York, NY: Teachers College Press.

Snow, C. E. & Dibner, K. A. (eds). (2016). *Science literacy: Concepts, contexts, and consequences*. Washington, DC: The National Academies Press.

Stornaiuolo, A. & Nichols, T. P. (2018). Making publics: Mobilizing audiences in high school makerspaces. *Teachers College Record*, 120(8): 1–38.

Vanderhoof, C. M. (in press). Multimodal analysis of decision making in elementary engineering. In G. J. Kelly & J. L. Green (eds), *Theory and methods for sociocultural research in science and engineering education* (pp. 48–72). New York, NY: Routledge.

Vartiainen, J. (2017). *Poetry Science*. Retrieved from: www.monilukutaito.com/en/blog/39/poetry_science, 26 October 2018.

Vartiainen, J. & Kumpulainen, K. (in press). Promoting young children's scientific literacy: Scientific literacy as a social practice. In K. Kumpulainen & J. Shefton-Green (eds), *Multiliteracies in Finland and beyond: International perspectives on an early year's innovation*. London: Routledge.

Vossoughi, S. & Bevan, B. (2014). Making and tinkering: A review of the literature. Commissioned paper for Successful Out-of-School STEM Learning: A Consensus Study, Board on Science Education, National Research Council, Washington, DC. Retrieved from: http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_089888.pdf, 29 October 2018.

Vygotsky, L. (1976). Play and its role in the mental development of the child. In J. S. Bruner, A. Jolly & K. Sylva (eds), *Play: Its role in development and evolution* (pp. 537–554). New York, NY: Penguin Books.

Vygotsky, L. (1978). Interaction between learning and development. *Readings on the Development of Children*, 23(3): 34–41.

Vygotsky, L. (1986). *Thought and language*. Revised edition. Cambridge, MA: MIT Press.

Vygotsky, L. (2004). Imagination and creativity. *Childhood Journal of Russian and East European Psychology*, 42(1): 7–97.

Wohlwend, K. E., Scott, J. A., Yi, J. H., Deliman, A. & Kargin, T. (2018). Hacking toys and remixing media: Integrating maker literacies into early childhood teacher education. In S. Danby, M. Fleer, C. Davidson & M. Hatzigianni (eds), *Digital childhoods* (pp. 147–162). Singapore: Springer.

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