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Interactive science in a sociocultural environment in early childhood

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This article aims to give a practical overview of science in early childhood education (ECE), including pedagogical practices. Science is one of the learning areas with a lot of content knowledge, encompassing key scientific understandings of the natural environment, plants, human beings and animals, interacting substances and elements and knowledge about planet Earth and beyond. Research argues that children have science content knowledge prior to attending preschools, which connects to more advanced science areas like biology, chemistry, psychology and physics (Brenneman 2010; Metz 2009 as cited in Pendergast, Lieberman-Betz & Vail, 2017). *However, this scientific knowledge needs to be identified and nurtured at the grass root levels by teachers. Teachers who have a large concept knowledge base are able to identify relevant science linked to children's current interest and prior knowledge and are able to introduce children to science in meaningful and memorable ways through their sociocultural environments.*

Sociocultural context in early childhood education

Two theories that inform sociocultural practices in ECE are Vygotsky's and Bronfenbrenner's theories. Vygotsky's (1978) contribution to ECE pedagogy gives us an understanding that learning is enhanced through dialogue at an individual level and in small groups, whereas Bronfenbrenner's (1979) bio-ecological theory draws our attention to factors that affect the child's direct environment at the centre and at home (the micro-system) and how interactions between teachers and parents (meso-system) can help strengthen the connections between these micro-systems, and therefore the child's learning.

Despite these theoretical understandings, many teachers are finding it challenging to get a clear picture of how this sociocultural theory translates into practice. Ritchie (2010) argues that there seems to be little research to imply educators' understanding of the sociocultural curriculum to their practice. The term cultural often leads to the erroneous belief that sociocultural practice is about learning about cultures. While sociocultural practice can certainly be linked to the child's culture, learning about their own and others' cultures is not the only objective of sociocultural practice. Instead, sociocultural practice is first and foremost about the child. Planning and learning starts from the child, with the child's thinking and ideas. Sociocultural theory sees the child in the context of their environment, which includes the multitude of interactions with their teachers and peers in the early childhood centre and the wider context of the families attending the centre. This context is about people, places and things important for the child, and events in the child's life that are particularly relevant and meaningful to the child in that moment in time (Ministry of Education, 2017). For example, going on fishing trips could be part of the culture of the child's family. Culture includes the impact of the family make-up and how the child experiences day-to-day interactions with people in their direct environment. Culture in this sense means "the understandings, patterns of behaviour, practices, and values shared by a group of people" (MoE, 2008, p.5). Therefore, sociocultural is not so much about the ethnic culture but more about the context of the centre (environment, space, resources, interactions, people, teaching pedagogy and curriculum) and possibilities and opportunities awarded by the home environment and neighbourhood as well as challenges and limitations.

When planning to extend learning based on a child's interests, an important point to consider is that *Te Whāriki: He Whāriki Mātauranga mō ngā Mokopuna o Aotearoa: Early Childhood Curriculum* (*Te Whāriki*) (MoE, 2017) aims for children to develop agency in their learning. Agency has to do with self-determination, contribution and involvement in self-initiated activities (Carr & Lee, 2012). As competent and capable learners, children are showing an interest in their environment and indicate what they want to find out about. The teachers' role is to look out for and be curious about the child's questions, thinking and developing working theories on what they are observing. Parents and teachers can foster a 'culture of observing and inquiry', model 'making guesses and predictions', encourage children to look closer and observe longer, and describe not only scientific phenomena but also the mathematical, literacy and technological concepts happening simultaneously and developing learning dispositions such as thinking and communication skills in a holistic manner (Hamlin & Wisneski, 2012; Te Papa Tongarewa, 2015).

The nature of science

The nature of science is that it is happening all around us all of the time, just like mathematical concepts being part of everyday life. Teachers can model curiosity and close observation of phenomena by pondering, "I wonder…" as an invitation to the child to respond, mimic the 'noticing' or ask questions about the concept (Te Papa Tongarewa, 2015). Noticing and naming scientific concepts in children's play and allowing time for children to investigate this as part of their play allows children to explore without interrupting their play (Hedges, Cullen & Jordan, 2011). A noticing/describing comment can invite the child to engage in conversation but does not compel the child. The objective is to learn about science through play and real life events that are meaningful to the child, having an image of themselves as a scientist who observes, records (by making a drawing or taking photos of their observations), considers similarities and differences and develop working theories about cause and effect (Hamlin & Wisneski, 2012; Hedges & Jones, 2012; Te Papa Tongarewa, 2015).

In order to model scientific practice, teachers need to model being observant, and be active participants who have a good science knowledge base and knowledge of the child. Sociocultural practices as described above involve active dialogue between children teachers, parents and peers (Te Papa Tongarewa, 2015), making connections across home and centre contexts and experiences. For example, McLachlan, Fleer, and Edwards, (2010) extend on Vygotsky's idea of how everyday concepts that children relate to could be mediated by teachers through dialogues into formal concepts such as wiping of the table could be linked to the concept of 'area'. Consequently, teachers' knowledge about science and their knowledge of the children's interest and development also guides facilitation of an interactive environment with opportunities for science exploration that are meaningful and purposeful (Fleer, Gomes & March, 2014). Preparing the environment requires reflective practice and a readiness to respond. Teamwork and parent partnerships are important elements of intentional teaching practice because our practice is stronger and more meaningful when we share our observations, parents' and children's voices with our colleagues. Parents' voices add to the learning when new information is shared that connects the learning at the centre to learning experienced at home (Cooper & Hedges, 2014; Esteban-Guitart & Moll, 2013). This helps the child make more connections across settings and increases their participation in continuing their learning journey. The following sections will give some examples of scientific concepts often seen in children's play to help teachers recognise opportunities for learning.

The living world

The living world includes children's understandings about their own bodies, what they are able to do and how their body works, while the natural environment includes knowledge of nature such as flowers and plants (a vegetable garden, for example) and the animal world (pets and bugs, for example). This includes the different types of animals a child encounters during special outings, such as going to a farm, zoo, a visit to the park or a duck pond or aquarium.

Learning is most effective at this age when the child is setting the tone and pace for the investigation, when the learning is age appropriate and links to their prior knowledge. In this sense, the child's own contributions, offerings of ideas is the right place to start from. Rather than thinking "what do I want to teach the child about their body, pets or zoo animals?" a better way is to wonder what the child is feeling curious about at that moment in time. A good question to ponder would be "How can I invite the child to share their ideas/ thinking with me?" For example, if we observe children engaged in pretend play taking their puppy for a walk; it would be a good idea to ask about their own experiences with dogs, rather than asking "How many legs does the dog have?" In early childhood education it is all about their own experiences (opportunity to include literacy when writing their dog's name on the drinking bowl), the size of their dog (mathematics) and their characteristics (which is the science part). Further investigation into science comes from the child's questions and observations about their dog, characteristics and needs for living and hygiene. How is your dog different from other animals? Why can you teach your dog tricks for example and not your cat? What are the dog's needs (food; exercise) as opposed to the cat or other animal they know? Teachers encourage children to find answers to their questions in collaborative ways, discussions, sharing their knowledge and working theories, using books and resources in the centre and home environment. Making these investigations public (individual documentation in physical portfolios and electronically) and displaying the learning journey of a group of children on the wall, helps children, parents and teachers to contribute to the discussion and revisit and extend on the learning.

Preparing an interactive environment

Children learn most from interactive environment including interactive displays such as growing and watering plants, exploring the parts of a plant, or observing differences in the growth of plants when teachers display one of the plants deprived of water or light. Findings can be described, recorded, discussed, and compared. It is the describing part that provides knowledge of the learning content (Fleer et al., 2014). Here the teacher may do some research (preferably together with the children). Getting an understanding of photosynthesis for example enables the teacher to extend on the plant investigation: "Why do plants need water and light and what is the plant doing with the light and water? How does the plant 'suck' the water up?"

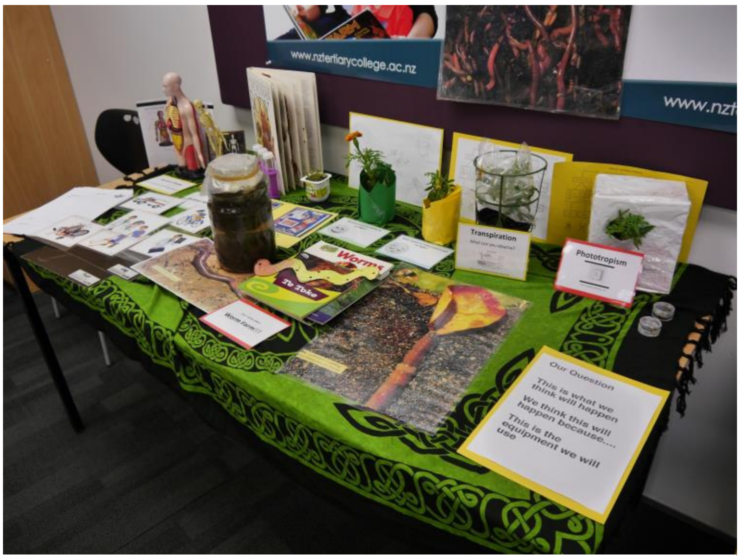

Figure 1: Worm 'house' and living world display to explore at the symposium session (NZTC, 2017).

Teachers need to be enthusiastic and fascinated about learning and discoveries taking place and model curiosity, close observation and investigation themselves. When making a new discovery, teachers make it very clear that a new discovery has been made by expressing their excitement and talking about what has been discovered, sharing this with all the children, making sure that each child in the group has understood the key concepts. Using scientific vocabulary helps to develop children's working theories (Areljung & Kelly-Ware, 2016). Giving children time to process and formulate their own thoughts helps children develop confidence as a learner. Peters and Davis (2011) explain that even though working theories can appear 'incorrect' to an adult but a closer examination of a working theory often leads to the realisation that the child's explanation 'fits' with their current knowledge and understanding of the world, so it is age-appropriate to acknowledge the child before further exploration takes place. Teina-tuakana relationships offer opportunities for older children to share their knowledge with the younger ones. Through the pedagogy of 'ako' (reciprocal teaching and learning) both the younger child (teina) and the older child (tuakana) can add their knowledge. Te Papa Tongarewa (2015) explains "this is empowering as it means that the children are recognised as being sources of expertise, not just the adults" (p. 15). Te Papa Tongarewa (2015) also recommends teaching children the values of kaitiakitanga (guardianship), manaakitanga (kindness), and mauri (respect for all living things) to ensure proper care for animals and plants.

Material world

Apart from learning about their own bodies, which is part of learning about the natural world, infants and toddlers also learn with their own bodies, that is through all their senses about the material world (Hamlin & Wisneski, 2012). Through touch, sight, smell, taste and hearing infants and toddlers discover many different properties of different substances and natural materials. The material world is predominantly about how substances change and what makes them change. While it is fun to come up with as many describing words as you can for the younger age group, older children can share their ideas on what made the ice melt, why the playdough is slushy or dry or what made the condensation on the window on a freezing winter day. All these observations about the world help the child form understandings about their environment and the relationships between changes happening in their environment.

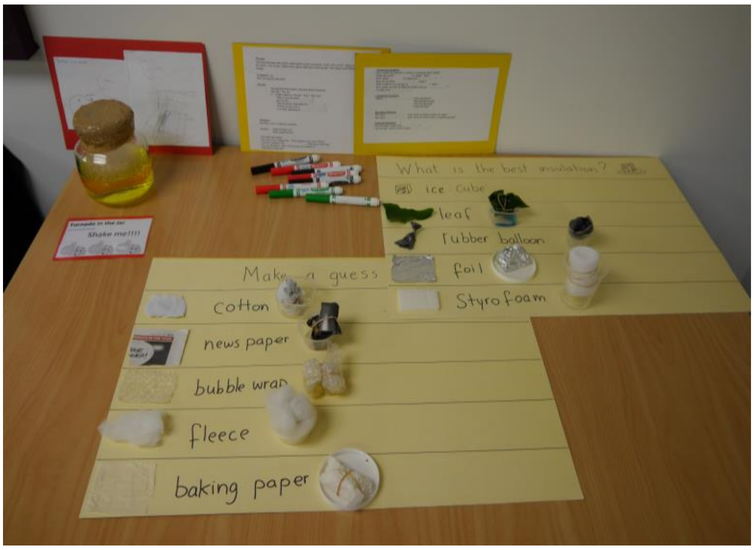

Figure 2: Materials wrapped in different insulation materials for interactive exploration (NZTC, 2017).

The properties of substances may undergo changes through the processes of mixing, freezing, dissolving, absorption and cooking and children are able to observe changes in shape, texture, colour, size, and smell. To explore the material world, early childhood teachers can consider hands-on activities such as finger-painting, playdough, clay, paper mache or mixing dough for biscuits or a cake. Working with different kinds of materials at the art or carpentry area also comes under the material world, for example by investigating the properties and use of wood, metals, paper, plastic, glues and so on. In the outdoor environment children explore the properties of rocks, shells, sand, water and more. An interactive science area often includes materials of different textures and intricate aspects such as rocks, shells and materials, which can be explored with the help of a viewer or magnifier glass.

Some of the processes that children observe are reversible such as the process of freezing and melting ice. Others are irreversible, such as the cooking of rice. Older children enjoy working with materials. However, extra care needs to be taken when materials and substances contain poisons such as detergent, polystyrene, Styrofoam, solvents (glues), compost, fertiliser, cement, permanent markers or fine particles such as glitter (Te Papa Tongarewa, 2015). Poisonous fumes or dust are released particularly when substances are mixed. Therefore, this needs to be done by adults beforehand, away from the children. In the natural world, health and safety also needs to be considered as there may be irritants, such as plants and foods that can cause allergic reactions.

Physical world

The physical world gets often associated with science experiments but it is also possible to recognise phenomena that happen spontaneously in children's play. An interest and subsequent investigation into physical phenomena such as force, gravity, sound, and shadows (light), can develop spontaneously for example, when children are pushing their cars down a ramp or investigating their shadow on a summer's day. Crucial is to use the scientific terminology to identify the concepts that are happening at the time and knowing how to further investigate these. Te Kete Ipurangi [TKI], a website of the New Zealand Ministry of Education gives good overviews of the concepts. It also indicates how different strands of science can be explored simultaneously in a holistic way. The root system of a plant, which holds up a plant, discovered by a child during gardening, can be compared to manmade structures, looking at the strength of different materials holding up a building (material world) and forces impacting on the structures (physical world). This can then also be compared to our own structures (skeleton) that hold up our bodies (MoE, 2018b; MoE, 2018c). Again, making sure the children have access to the appropriate resources is key (hands-on resources and activities), the opportunity to discuss concepts and draw comparisons to everyday life (sociocultural curriculum!) and documenting and comparing understandings. Children can make drawings of their beginning working theories. By comparing each other's drawings with one another and discussing these they can develop a greater understanding of underlying scientific concepts (Te Papa Tongarewa, 2015; MoE, 2018a).

Another example of holistic investigation of science concepts is the discovery of shadows. The physics concept is that light travels in straight lines. This combines with an investigation on where this light comes from (i.e. the Sun) and how the Earth by rotating creates different shadows throughout the day (a concept that links to the strand Planet Earth and Beyond). The third component of this investigation is the material involved and how much light this material is letting through. Building an understanding of the science concepts involved (see the resources from the TKI website), helps the teacher to set up the right environment and resources to help the children 'discover' the different concepts involved, including modelling some of the 'noticing' and posing open-ended questions for further inquiry. These open-ended questions can also come from children's observations/noticing's, highlighted by the teacher and converted into a scientific enquiry/ open-ended question. For example, when children observed their tower swaying and nearly falling down it was recognised by the teacher as concept development around gravity, structure and balance. Hence, the teacher could ask which side was heavier, leading to the structure losing its balance?

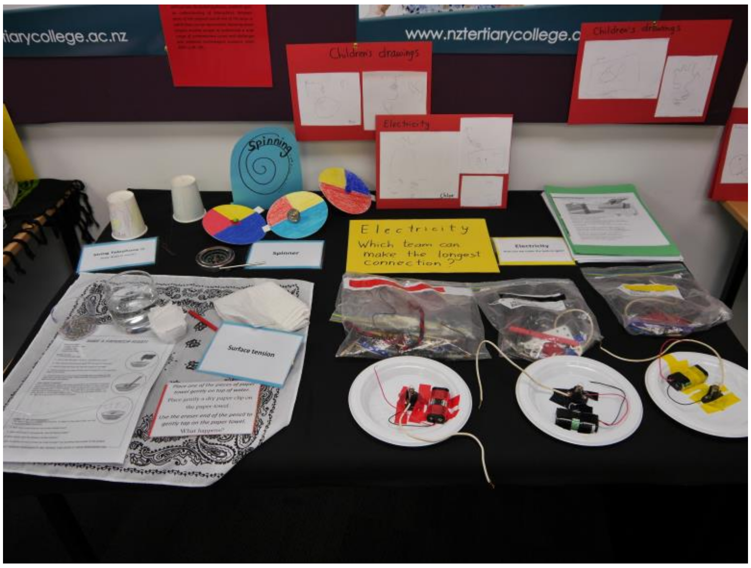

Figure 3: Display showing ways to explore the concepts of 'surface tension' and electricity with children's drawings of the electric circuits they made (NZTC, 2017).

Planet Earth and beyond

The planet Earth and beyond includes Earth formations, climate, and the interrelationships between the Earth, Moon, Sun and solar systems with water and life on Earth. Many interests linked to planet Earth and beyond link to the living world, material and physical world and are good topics for extended exploration and discussion around working theories. Where does the moon go during the day, might be one such question, or where does the rain come from?

Often natural phenomena are noticed during a change of seasons, where weather changes impact on humans, plant and animal life. Exploring each season as it comes around provides a lovely sense of rhythm to the year and gets children involved in kaitiaki (caring for) the gardens, animals and themselves! This can be linked to ongoing projects such as caring for the environment, recycling, water-preservation, composting, having a weather station, planting seeds, reaping produce and preparing the land again.

Planet Earth and beyond provides great opportunities to learn about and connect to Māori kaupapa and tikanga around caring for the environment. Many legends are connected to nature and how to look after the environment. Also, land formations, and natural land marks play a major role in learning about kaupapa, tūrangawaewae (place of standing and lineage) and how people are connected to the land and collectively look after the land (MoE, 2009). Māori had great knowledge of the stars, sea-swells, navigation and land formations, so learning about children's local environment builds important connections to the environment and fosters belonging. Important landmarks can be woven into children's pepeha (indicating where they come from).

Much of science investigation is about relationships: the relationship between changes in the environment and the weather pattern for example, or changes taking place during growth and investigating cause and effect. Children are encouraged to make predictions and offer their latest 'working theory', share their ideas and ask questions. The basis of effective inquiry skills are good observation skills and seeing themselves as 'explorers' (Te Papa Tongarewa, 2015). Te Papa's science learning resource gives an overview of the scientific processes which are to explore (interactive), ask scientific questions, make hypotheses/predicting ("I wonder…"), observe (using all senses), make meaning (collaborative) and conclusions - share findings.

Much concept knowledge is shared during science investigations so it is important to allow ample time to explore and process information (for example, by asking the children to make drawings and take photos). Cross-referencing and rich learning opportunities arise by providing books, Information and Communications Technology (ICT) and inviting teachers' and parents' expertise.

Conclusion

This paper discusses the practical aspect of science in an early childhood environment and how teachers could empower children to co-construct science knowledge, through a sociocultural lens. This paper further specifies the sociocultural theory in an attempt to enhance teachers' understanding of the pedagogical practices in identifying and engaging with scientific teaching moments in early childhood education. Children have prior knowledge in science areas (Brenneman 2010; Metz 2009 as cited in Pendergast, Lieberman-Betz & Vail, 2017), and therefore, it is the responsibility of the teachers to nurture this knowledge in order to lay a strong foundation of science for these children as articulated under the science strands: Living World, Material World, Physical World and Planet Earth and Beyond (MoE, 2007).

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