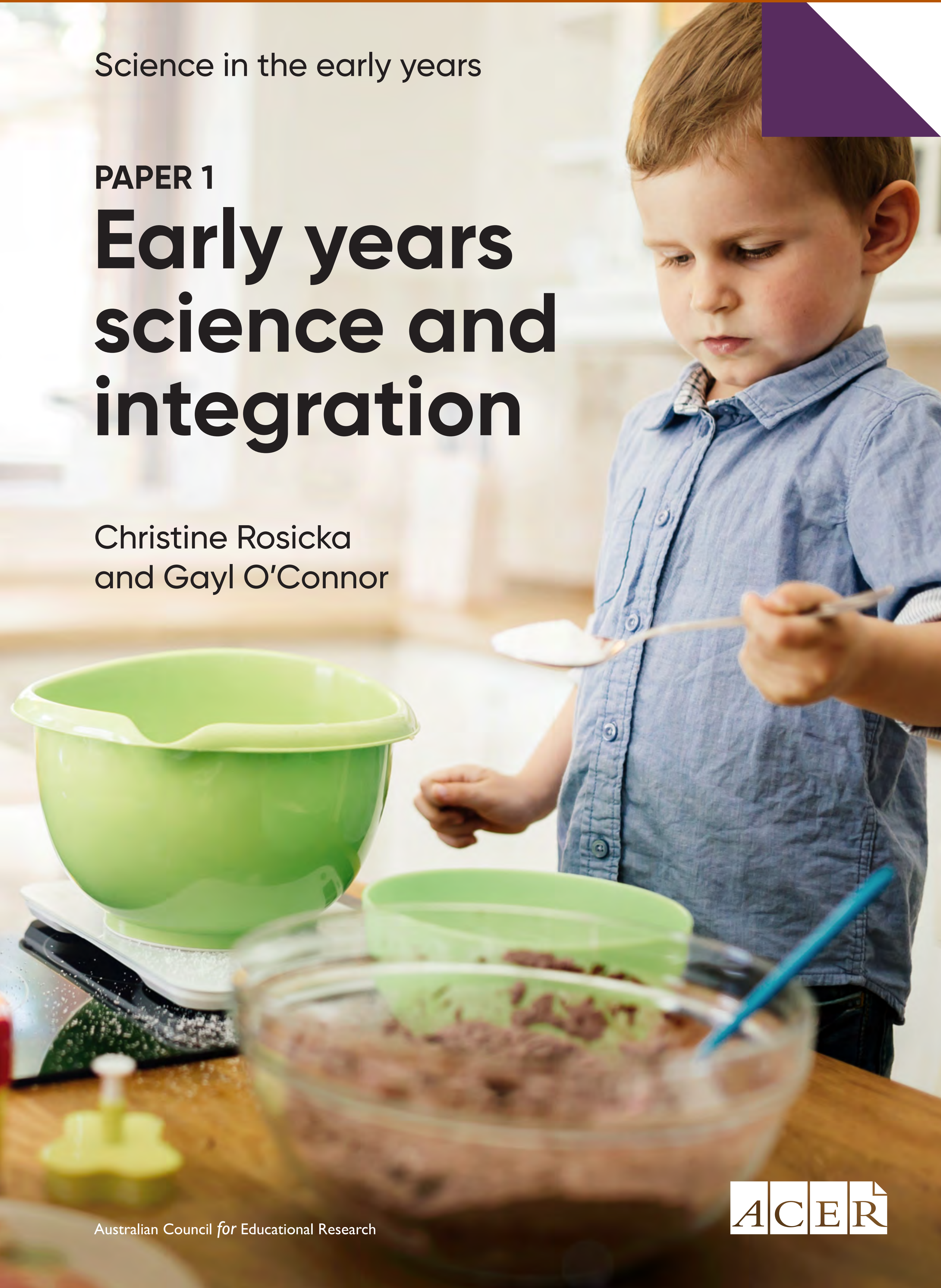

Science in the early years

PAPER 1

# Early years science and integration

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# Contents

# Introduction

This is the first paper in the *Science in the early years* series that reviews current research into science learning and monitoring in the early years. The aim of this series is to provide early years educators with an insight into current research; highlight how research findings relate to children's science learning; look at the current understandings about early years science monitoring; and provide examples of how early years educators can incorporate this research into their practices.

This series defines 'early years' as the two years prior to school and the first three years of primary school, which in Australia generally includes children aged three to eight years. Children in the early years may attend early childhood centres, kindergartens or primary schools. Educational expectations for children of this age range are covered by the Early Years Learning Framework (EYLF) for preschool children, and the Foundation to Year 2 Australian Curriculum (AC) for school students.

This paper focuses on the importance and value of science in the early years, how teaching science is supported by the EYLF and the Foundation to Year 2 AC, and the value of integrating science in the early years. We also provide examples of resources that can support educators and children to recognise the elements of science in simple, everyday activities used in early years settings.

The *Science in the early years* series reviews Australian and international research to highlight aspects of the learning and monitoring of science in the early years that are significant to Australian children and their educators.

# Science in the early years

Science in the early years doesn't need to be daunting for educators or young learners. It need not involve additional work to develop new activities, or money for special or new equipment. Many common activities in early years education, such as painting, classifying, cooking, building and sorting, have a basis in science. It is important that the scientific nature of these activities is highlighted and discussed in early years settings.

Science is the process of understanding the world (Peterson & French, 2008) and should be seen as a way of approaching an activity, not just as the activity itself (Conezio & French, 2002). This means that science involves not just *doing* but *thinking* and *talking* about the work being done (Gelman & Brenneman, 2004). The essential science inquiry skills of predicting, exploring, observing, reporting and communicating should be emphasised through early years science (and will be explored in detail in the second paper in this series). Science learning in the early years should be a collaboration between educators and children to explore the world around them and develop age-appropriate science skills and knowledge.

## The importance of science learning in the early years

Before starting school, young children are learning and developing science concepts as they experience the world around them, in the same way that they are learning about language and mathematics in their interactions at home and in the community. Developing science concepts from an early age is important as science is *everywhere* (Tu, 2006) and early science learning can harness young children's natural curiosity and motivation to learn about the world around them (Henrichs & Leseman, 2014). Science can also build on young children's developing interests and their previous experiences as it engages and supports their learning and development (French, 2004).

Science concepts should be introduced in the early years, with a focus on what students are interested in (Dogru & Seker, 2012). Including science learning in early years educational settings further supports young students to develop their understanding of science concepts and therefore increase their understanding of the world.

Science is a way for young children to develop their understandings of the world they live in.

Young children are keen and inquisitive learners. Science learning in an early years context can encourage children to explore their environment and nurture their sense of curiosity about their surroundings (Milford & Tippett, 2015). One of the main objectives of an early science program is to foster children's scientific curiosity and question-asking skills (Jirout & Klahr, 2011). It is important to develop and support this natural curiosity as it is recognised as an essential trait for a scientist and a successful science learner (Conezio & French, 2002; Gallenstein, 2005). Developing young children's natural curiosity can also help them develop their identity as learners and legitimate scientists.

As well as being curious, it is important that young children understand that taking risks and making mistakes are a part of successful learning (Lottero-Perdue, 2016) and that learning is not always about getting things right or being correct. Science can teach young children that it is acceptable to fail and that learning can come from making mistakes. Scientific inventions often come from eager, persistent, determined individuals who have been willing to try new avenues in spite of failure. Making mistakes or failing can result in significant benefits to learning and help children develop positive attitudes to failure (Gallenstein, 2005). Young children may be more willing to take risks and to accept mistakes than older children, so it is important that these traits are encouraged and developed from a young age if they are to be further developed as students get older.

One way that science can be used to model taking risks and developing a positive attitude towards failure is by asking children to hypothesise and test out theories that will not always be correct. For example, children can take risks by hypothesising about items that might float and sink and then test their hypothesis in a hands-on way by experimenting with various items, and collecting and assessing evidence through their own experiments. This type of activity supports the three cognitive components of scientific reasoning according to Klahr's 'Scientific discovery as dual search' model (van der Graaf, Segers, & Verhoeven, 2015), which are hypothesis generation, experimentation and evidence gathering. These three aspects of scientific reasoning can be fostered and developed from an early age with the assistance of educators. Having children take risks and see that their thinking is not always correct can help them understand that science is not just about learning facts and being right: it is about trying things and finding out.

Educators must prepare today's children to question, think critically, problem-solve, and make well-informed decisions that will affect society. Along with the development of thinking skills, educators must also foster scientific attitudes.
**Gallenstein, 2005, p. 29**

It is important for young students to believe in themselves as capable and confident science learners and not to see science as something that only older students or adults can do. Australia's National Science Statement (Australian Government, 2017) recognises that early childhood educators and primary school teachers have an important role to play in fostering children's scientific learning and in encouraging their interest in science. This role includes helping children to see themselves as successful science learners from a young age so that they can apply this attitude to their later learning.

# Science in the Early Years Learning Framework

Recognition of the importance of children's learning before primary school has grown over the past decade. In 2008, a research paper was written (Edwards, Fleer & Nuttall, 2008) that informed the development of *Belonging, being and becoming: The Early Years Learning Framework for Australia* (EYLF) (Australian Government, 2009). The EYLF has been developed for early childhood educators to support young children and lay the foundations for successful lifelong learning. The Framework includes principles, practices and learning outcomes for children in early education from birth through to their transition into school (Australian Government, 2009). This paper focuses on the EYLF as it applies to children in the two years before school, when children are usually aged between three and five years.

## Outcomes of the EYLF

The EYLF (Australian Government, 2009, p. 19) has five outcomes:

### Outcome 1
Children have a strong sense of identity.

### Outcome 2
Children are connected with and contribute to their world.

### Outcome 3
Children have a strong sense of wellbeing.

### Outcome 4
Children are confident and involved learners.

### Outcome 5
Children are effective communicators.

The focus of the EYLF learning outcomes are deliberately 'broad and observable' (Australian Government, 2009) and are not content specific as they are in the Australian Curriculum; however, they still provide scope for supporting science learning. To further support children's development, each of the five EYLF outcomes is reinforced by key components.

There are numerous ways in which science learning activities that link to relevant EYLF outcomes can be applied in an early childhood context. The following page provides examples of some of the EYLF outcomes and key components that support science and includes practical ways for educators to either introduce science or understand that science is already part of their practice.

## Outcome 2

Children are connected with and contribute to their world.

### Key components

Children become socially responsible and show respect for the environment.

### Links to EYS

Learning activities that focus on the environment could support children to develop their science understanding related to this key component and outcome. Such activities link science back to the young child's world and make it relatable to their everyday.

### Supporting activities

- Explore the children's immediate natural environment. See plant treasure hunt activity.
- Classifying living and non-living things. Determine the characteristics of each group. Record predictions, observations and understandings.

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## Outcome 4

Children are confident and involved learners.

### Key components

Children develop dispositions for learning curiosity, cooperation, confidence, creativity, commitment, enthusiasm, persistence, imagination and reflexivity.

### Links to EYS

Science can help develop children's curiosity about their world (Milford & Tippett, 2015). Science is also a great way for young children to work together (Gelman & Brenneman, 2004). The focus of supporting activities is not just for learners to develop scientific content but to understand the scientific skills as well.

### Supporting activities

- Sinking and floating activity where students need to demonstrate persistence in finding objects that float.
- Activities that involve air and bubbles can foster children's curiosity and begin to develop their understanding of reflexivity, that is, how things affect each other.

These are examples of activities that may be commonly used in early years education settings and do not require special scientific equipment.

## Outcome 4

Children are confident and involved learners.

### Key components

Children develop a range of skills and processes such as problem solving, enquiry, experimentation, hypothesising, researching and investigating.

### Links to EYS

These skills are a fundamental part of the Science Inquiry Skills (SIS) that are also embedded in the Australian Curriculum: Science (Australian Curriculum and Assessment Reporting Authority [ACARA], 2016) and recognise that science learning is not limited to gaining knowledge, it is also about developing scientific skills. The development of such skills can be fostered in an early childhood context through creative and play-based learning and more structured teacher-led activities that allow children to build on their experiences (Andersson & Gullberg, 2014).

Supporting experiences can also foster the development of SIS, which are recognised as a vital component of early years science learning. The inquiry strategy of 'observe, predict, check, record' is suggested as a good framework for developing SIS and science content in young students (Gelman & Brenneman, 2004). Using consistent strategies allows young students to practise and develop their skills as they acquire new knowledge.

Following a recognised scientific process can also help young students to see themselves as capable science learners and help to develop their confidence when learning science.

### Supporting activities

- Melting and freezing ice cubes.

  Ask children to use their senses to observe water in an ice cube tray, then predict what will happen when they place the ice cube tray in the freezer, check what happens after a few hours, then record the process (draw or describe the change) and their findings. It is important that educators consistently model scientific language, such as observing, predicting, hypothesising, and recording during such tasks.

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## Outcome 4

Children are confident and involved learners.

### Key components

Children transfer and adapt what they have learned from one context to another.

### Links to EYS

The development of reasoning based on evaluating evidence emerges during the preschool and early primary years (Piekny & Maehler, 2013). Science can be a way of allowing young learners to develop new understandings and apply them to new contexts (Gelman & Brenneman, 2004), thus showing them that what they have learnt can be applied to different situations. At the preschool stage, children can evaluate evidence when all examples support the same conclusion (Piekny & Maehler, 2013).

### Supporting activities

- Explore the colours and patterns of familiar insects that make them difficult to see in their natural environment, then apply their understanding of the concept of camouflage to an unfamiliar example, such as pictures of antelopes in their environment.
- Drop a golf ball into a sandpit, notice that every time the object falls straight downwards the sand moves away from the impact site. Children can then make a prediction about what would happen if they dropped different balls into the sand based on their comparisons.

### Outcome 5

Children are effective communicators.

#### Key components

Children interact verbally and non-verbally with others for a range of purposes.

Children express ideas and make meaning using a range of media.

Children begin to understand how symbols and pattern systems work.

#### Links to EYS

Communication is an important part of the scientific process (Conezio & French, 2002; Gallenstein, 2005) that young learners should practice. Effective communication skills are not limited to science, although science can provide the content and experiences to support young students' communication skill development. It is important that as part of developing SIS, children's methods and discoveries are recorded and reported to show what they have learnt and reflect what they have done. Children in the early years should start to document their methods and findings using drawings, or with educator assistance, allowing science to be integrated with literacy.

#### Supporting activities

- Scribe for children or have children draw pictures about what they have done or verbally report what they have found.
- Have capable children record their own predictions, observations, methods and findings so that they can be communicated just as real scientists do.

Although there are no specific requirements for science in the EYLF, there are numerous opportunities for science learning to support children to meet the outcomes of the framework. The examples provided demonstrate the connections between the EYLF outcomes and the possibilities for science learning to contribute to children's development in early childhood contexts.

# Links between the EYLF and Australian Curriculum: Science

Although they are quite different in structure and content, there are a number of links between the EYLF and the Australian Curriculum: Science. The EYLF, as noted previously, has broad, non-subject specific outcomes that focus on the development of children's identity and wellbeing as well as their interpersonal skills (Australian Government, 2009), whereas the AC focuses on subject-specific outcomes. For science, there are three strands: Science Understanding (SU) (specific science content development), Science as a Human Endeavour (SHE) and Science Inquiry Skills (SIS), (ACARA, 2016). The EYLF and the AC vary as they address different phases and learning stages of young students (Edwards et al., 2008); however, it is important to note that the AC builds on the learning children achieve under the EYLF and recognises that young students in the first years of school have particular needs and entitlements (Connor, 2012). The two documents are described as being complementary and are considered to provide a pathway for learning from 'prior-to-school, into school and beyond.' (Connor, 2012, p. 6). While the EYLF provides scope for science learning in the early years, the AC builds on this and includes science as a specific learning area.

The content-specific descriptions and key ideas in the Australian Curriculum: Science, Foundation level show considerable cohesive, mutually supportive links between aspects of the EYLF. For example, in the Science Understanding strand, one of the content descriptions is 'Living things have basic needs, including food and water' [ACSUU002], which is closely aligned with the EYLF Outcome 2, 'Children become socially responsible and show respect for the environment'. Respect for the environment supports an emerging understanding of the needs of the living (and non-living) components of the environment.

Science inquiry skills are a fundamental part of the AC. However, the development of such skills should begin before children reach primary school. At Foundation, the SIS strand (ACARA, 2016) has four aspects:

- Pose and respond to questions about familiar objects and events [ACSIS014].
- Participate in guided investigations and make observations using the senses [ACSIS011].
- Engage in discussions about observations and represent ideas [ACSIS233].
- Share observations and ideas [ACSIS012].

All of these early aspects of inquiry link to EYLF Outcome 4, where 'Children develop a range of skills and processes such as problem solving, enquiry, experimentation, hypothesising, researching and investigating' and to Outcome 5 'Children are effective communicators' (Australian Government, 2009). The second paper of this series *Science inquiry skills* explores SIS in detail and looks at how these skills can be developed in all early year's educational settings, not just in primary school.

Although the AC is content-specific, it also recognises six key ideas for Science: Patterns, order and organisation; Form and function; Stability and change; Scale and measurement; Matter and energy; and Systems (ACARA, 2016). These key ideas are intended to guide the teaching and learning emphasis for each year level across all three strands of SU, SIS and SHE. The Australian Curriculum: Science provides an overview of how students progress through each of these key ideas from Foundation to Year 10. For the content descriptions, there are clear parallels to aspects of the EYLF outcomes. For example, in order for children to begin to recognise patterns and relationships and the connections between them, a key component of Outcome 5 of the EYLF is: 'Children begin to understand how symbols and pattern systems work'. The AC key idea of Patterns, order and organisation also has a focus on recognising patterns in the world, but can extend this idea to a larger scale pattern such as global weather patterns.

Another example of the cohesiveness of the EYLF and the key ideas of science, is the key component of Outcome 2 of the EYLF: 'Children are connected with and contribute to their world.' The EYLF states that this becomes evident when children explore, infer, predict and hypothesise in order to increase their understanding of the interdependence between land, people, plants and animals. This is an early stage of understanding systems, where children analyse and show understanding of the way in which systems 'work', and leads to children developing the ability to understand, explain and predict real-world phenomena. For Systems, the AC states that 'initially, students identify the observable components of a clearly identified "whole" such as features of plants and animals' (ACARA, 2016, p. 7) or recognise the parts of a mixture (sand and water), illustrating how there are links across the EYLF and the AC for this key aspect of science. Systems can be studied at many levels, including observing and learning about the components directly from observation to understanding the complex and abstract interactions that exist within them. Both the EYLF and the first years of the AC focus on children's growing understanding of the world around them.

# Integration in the EYLF and in the Australian Curriculum: Science

Science is not something that needs to be taught in isolation from other learning areas. One of the benefits of early years science learning is the enormous scope to integrate it with other areas such as literacy and mathematics (Greenfield et al., 2009; Delserieys, Jégou & Givry, 2014) as well as the ability to reinforce and revise skills learnt in other content areas (Gelman & Brenneman, 2004; French, 2004; Hess, 2010). Literacy and mathematics skills are vital for science learning (Gelman & Brenneman, 2004) and support the development of science skills (Russell & McGuigan, 2016). Early years science activities can allow language and mathematical skills to be developed and revised as children experiment and discuss what they are doing and what they have found (Conezio & French, 2002; French, 2004). Using science as the central unit to develop knowledge and skills in other domains recognises that young children are holistic learners (French, 2004) and provides scope for children to develop their understandings of the world around them. For instance, there is value in setting science activities within the context of a story (Cavendish, Stopps & Ryan, 2006). Through listening to a story, children can gain an understanding of the purpose and reason for an investigation, and a story can help children become more engaged. An early years science program can also provide opportunities for children to develop their science vocabulary (French, 2004; Delserieys et al., 2014) as children are introduced to terms that support SIS such as observe, predict, check, and report (Gelman & Brenneman, 2004). Having the correct vocabulary helps children think, talk and work scientifically (Gelman & Brenneman, 2004), and develop and label their SIS and knowledge. The research-based Primary Connections (Australian Academy of Science, 2018) program recognises that science and literacy can be easily integrated and that this integration benefits young students to develop both their science and literacy skills in an inquiry-based program. The US developed ScienceStart! (ScienceStart!, 2018) preschool program also recognises the ability to integrate science with literacy and mathematics and provides a science-based preschool curriculum. Including science in the early years does not mean educators need to add more to their programs, rather, if science is cleverly integrated, it can mean that more skills and content can be covered at the same time.

Science and mathematics share many common ideas and skills that can be developed in the early years. These include measurement, number patterns, sorting and classification of objects and forming groups based on common characteristics. Inquiry-based science and mathematics activities can allow educators to effectively integrate mathematics and science so children can learn that both mathematics and science involve, for example, discovering patterns and relationships (Saçkes, 2013). Mathematics and science understandings can be introduced through young students exploring their world (Gallenstein, 2005). Children can explore the outdoor space to count how many different living things they can find and also begin to group these acording to their common characteristics such as the number of legs they have or whether they need sunlight to grow. It is important that the commonalities of mathematics and science are hightlighted to young students as they happen to help them develop these understandings.

Integration is also discussed in the EYLF and the AC in several contexts. The EYLF adopts an emphasis on holistic approaches to teaching and learning, which recognises the connections between mind, body and spirit (Australian Government, 2009). It looks at the *integration* of sensory, motor and cognitive systems demonstrated by children's development in both learning and physical aspects (Australian Government, 2009). The outcomes are also developed to capture the integrated and complex learning and development from birth to five years of age. Learning in relation to these outcomes is influenced by several factors, including the extent to which each child integrates learning, as they progress on their individual pathway towards the outcomes. The EYLF also describes children's learning as integrated and interconnected. The connections include both those between children, families and communities; and connections to the natural world as an understanding and respect for the natural world is fostered (Australian Government, 2009).

The term integration is used in two closely related aspects of the Australian Curriculum: Science. In the SU strand, science understanding is 'evident when a person selects and integrates appropriate science knowledge to explain and predict phenomena, and applies that knowledge to new situations' (ACARA, 2016, p. 7). Integration is also referred to in the relationships between strands. In the practice of science, the three strands SU, SHE and SIS are closely integrated. Student experiences of school science should mirror and connect to the way scientists work; the three strands of the Australian Curriculum: Science should be taught in an integrated way (ACARA, 2016). This leads to a view that science should be taught in a way that supports the development of connections between scientific knowledge drawn from the biological, chemical, physical and earth and space sciences; and should endeavour to be authentic, in that it reflects the way in which scientists work.

Integration has several meanings across the EYLF and Australian Curriculum: Science. However, each has a clear and consistent view that learning outcomes and specific subject matter content should not be taught in an isolated, fragmented way, but should be embedded within a broader framework of development and learning. In the early years of schooling, fostering opportunities for children to make connections across aspects of their lives, including those related to the environment and SIS, is of paramount importance.

# Summary

Young children are curious and inquisitive, they learn from their everyday experiences and not just in formal educational settings. Introducing science in the early years can harness children's curiosity and build on their knowledge of science concepts, which is further developed as they experience the world around them. Early years science allows children to explore, question and develop as learners. Young children are more accepting of mistakes and failure and fostering these characteristics from a young age through the experimental nature of science provides opportunities for children to learn from failure. Introducing science activities to young children and allowing them to make mistakes could build their confidence to take risks in their later education. Scientific learning from the early years also supports young children's development of critical thinking skills.

It is important to recognise that science is already a part of many activities undertaken in early years learning and that both the EYLF and the AC support and foster science learning. To assist young children's scientific understandings and learnings, educators should recognise the science in their daily activities and see science as an approach to learning not just as an activity. Integrating science into other aspects of young children's learning can help develop skills in science as well as literacy and numeracy.

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