Science in the early years

PAPER 3

Monitoring children's learning

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Introduction

This third paper in the *Science in the early years* series continues to review 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 monitoring early years science learning; 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 monitoring young children's science learning. We also provide examples of resources that can support educators to monitor science learning using everyday activities common 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.

Monitoring children's understandings of science

For educators to effectively help young children learn, it is important that they understand what children currently know, what is appropriate for children to know at a certain age, and how to direct them in the future (Masters, 2013).

Before planning and designing activities for early years science, educators should develop a sound awareness of young children's existing science skills and knowledge to identify what they understand and what could be introduced next. Monitoring and documenting children's learning and understandings allows educators to collect evidence about what young children know and can do and how their learning develops over time.

It is vital for educators to have an appreciation for young children's science understandings, not only because young children may have misconceptions but also because individual children may start from different points (Carey, 2000). Monitoring can be embedded into sequences of learning activities and does not require tasks separate from the usual learning program (Shepard, 2006 as cited in Chang, 2012). Well-planned early years science evaluations focus on educators observing, recording and reflecting on children's investigations of the world around them (Brenneman, 2011). These could consist of a variety of methods such as discussions with children, educator observations and children's work or portfolios, to provide educators opportunities to build awareness of the scope of children's understandings and to identify any misconceptions.

Providing evidence for educators

Monitoring young children’s understandings should evaluate the learning, skill or development of the child (Bass & Walker, 2015). When monitoring, educators should be ‘clinical, interpretative and analytical’ and record ‘the child’s learning, skills, development and understandings’ (Bass & Walker, 2015, p. 79). Educators should be the main audience for the information gathered (Bass & Walker, 2015) as they will be the ones to use their knowledge of the children to plan appropriate learning experiences in early years settings.

Evaluating children’s science understandings helps educators to plan for the science skills and knowledge that need to be covered. Science concepts, just as in any other domain, need to be taught in relation to what children already know (Delserieys, Jégou, & Givry, 2014; Milford & Tippett, 2015) so that the learning activities respond to young children’s needs (Cremin, Glauert, Craft, Compton, & Stylianidou, 2015). Using this knowledge means that educators are able to adapt science activities to meet the needs of children. This is important because if educators do not understand what the children already know then children may not be able to understand what is being covered (von Glaserfeld, 1986 and Resnick, 1987 as cited in Lind, 1998, p.12).

One of the reasons why young children may find science learning difficult is that they often have existing misconceptions when it comes to science concepts (Carey, 2000). These misconceptions can be highlighted through informal interactions. For example, when children show an interest in learning more about an insect or a nearby tree, educators can ask questions to determine what the child already knows and identify any misconceptions. In this way, educators can develop an understanding of children’s prior knowledge and modify learning experiences and classroom settings to meet young children’s needs.

It is important for educators to invest their time in improving their knowledge of what children can do and understand. Evaluating young children’s understandings in the early years is time consuming and therefore the information gained from it needs to add value to children’s learning and development (Bradbury, 2014). In an early years setting, this could be done as part of documenting what children have participated in during their day. ‘Learning stories’, which include photos and write ups of the activities children have participated in, connect parents to their child’s day. When preparing documents such as learning stories, educators could note what the purpose of the activity was, the learning intention, and how well the child understood the specific content covered. Including such information would provide both educators and parents with a deeper understanding of their children, what they are capable of, and what might need to be explored further. Some methods that can be used to monitor children’s science learning are discussed further in this paper.

Monitoring young children's science learning

Considerations

When planning and implementing monitoring of young children's science learning, there are a number of considerations that should be taken into account to help ensure that the monitoring is effective and informative.

Focus solely on science knowledge and skills

It is important to make science monitoring and evaluation tasks accessible for all children and ensure that they focus only on science skills and knowledge. Monitoring activities should not focus on numeracy or literacy skills (Beeth et al.,1999) as strong science skills and knowledge are not always reflected in strong literacy skills (Beeth et al., 1999). Having literacy or numeracy skills embedded in monitoring activities could result in children not being able to fully demonstrate what they know and understand. Educators could use picture cards and verbal instructions rather than written instructions to include all children in the activities. Recently, researchers worked with preschool educators to develop a valid assessment that is picture-based: The CIRCLE: Science & Engineering subtest (Zucker et al., 2016). It is a brief computer-based activity delivered on a tablet, designed to provide preschool educators with a tool to understand children's science and engineering knowledge in an early years context.

Science activities in the early years should be short and not exceed children's attention spans (Delserieys et al., 2014; Dogru & Seker, 2012). When engaging in activities to monitor children's science knowledge, children should be allowed to use concrete materials and abstract ways (drawings and diagrams) of showing their understandings and skills. Repetition and presenting both abstract and concrete representations of concepts can help young children grasp difficult science concepts.

Develop observation skills

Early years educators are not always confident in their own science skills, science knowledge or in their ability to monitor young children's science development. This may be because there is not always a strong emphasis on science in early years educator training (Brenneman, 2011). Educators may be more skilled at monitoring other learning areas, such as mathematics and literacy, compared with science (Saçkes, 2013). Educators can improve their overall science monitoring skills by developing their own observation skills; observing and interacting with children will give them information about children's learning and development. Providing activities, materials and posing questions will encourage children to explore and learn more about their environment. Using carefully developed science performance tasks and checklists, which specify what knowledge and skills should be observed, can support monitoring and allow educators to make consistent observations.

Use monitoring to reflect on teaching practices

Science evaluations will help educators understand whether their science activities and instructions are effective (Brenneman, 2011) and information gained should be reviewed to see whether there are any areas that individual children or the group as a whole have not understood (Hess, 2010). This also assists educators to reflect and evaluate their practices. The ways in which children's science understandings are monitored and what is evaluated should also be reviewed regularly to ensure that they reflect what has been covered in science activities (Hess, 2010).

Incorporate monitoring into science activities

Monitoring children's actions and responses to situations during science activities can provide educators with a timely way of evaluating and improving young children's science skills. In an experiment that looked at young children's abilities to control different variables, it was found that incorporating the monitoring process into the activity improved outcomes (van der Graaf, Segers, & Verhoeven, 2016). Children were challenged to design experiments using two ramps with up to four independent variables: weight of a ball, steepness of a slope, position of a starting gate and surface texture of a slope. The children needed to use the control of variable strategy (CVS), where all variables other than the one being investigated is held constant (Schwichow, Croker, Zimmerman, Höffler, & Härtig, 2016). Educators monitored children's understandings during the activity to ensure that they were developing an understanding of CVS and were able to adapt their responses accordingly. The experiment found that monitoring during the activity was an effective way to improve the outcomes for kindergarten children when evaluating their ability to use CVS. Research has also found that young children's science understandings can be more deeply understood through discussions during science activities, and that portfolios and recordings of these discussions and science activities can provide educators with a sound understanding of young children's abilities (Samarapungavan, Mantzicopoulos, Patrick, & French, 2009).

Link monitoring tasks to outcomes

Tasks designed to monitor children's science understandings should reflect the objectives of early years science teaching (Achieve, 2010). In an international science benchmarking review undertaken in the US, it was noted that Canada (Ontario), Hong Kong and England made strong connections between their learning outcomes and science monitoring to assist children to learn science (Achieve, 2010). The report found that these connections were important features of successful science programs. When looking at ways to monitor science learning in the early years it is important that the activities are able to provide evidence that individual children have met the desired outcomes of the EYLF and Foundation to Year 2 Australian Curriculum. Tasks should be linked to the learning outcomes so that it is possible to collect evidence of learning against these outcomes.

Evaluate skills not just knowledge

As discussed in Paper 2 of this series (O'Connor & Rosicka, 2020), science is not just learning a set of facts, it is about developing a way of thinking and a set of skills. Both the development of Science Inquiry Skills (SIS) and science content should be monitored (Beeth et al., 1999; Samarapungavan et al., 2009). It has been noted that one of the key instructional objectives of most early science programs is to foster children's scientific curiosity and question-asking skills (Jirout & Klahr, 2011). However, monitoring generally focuses on science content knowledge, rather than SIS and should be expanded to include both.

Methods

This section describes a number of developmentally appropriate ways that young children's science skills and understandings can be monitored to ensure that they are given every opportunity to demonstrate their skills and abilities. Children's thinking and engagement can be understood by using various methods such as observation, discussion, work samples, drawings, stories, and play (Hess, 2010; Beeth et al., 1999; The Scottish Government, 2013). Activities need to be practical and simple for educators to implement.

Use drawings as an evaluation tool

Drawings can be an effective way to monitor children's understandings. It is well recognised that they are a valuable and non-threatening way to identify children's understandings and misconceptions and provide a means to track their increasing understanding and knowledge (Chang, 2012; Cowie & Otrel-Cass, 2011; Dogru & Seker, 2012; Milford & Tippett, 2015). If a child cannot visualise and represent a concept, it can mean that they do not understand it (Chang, 2007; Fello, Paquette & Jalongo, 2006/2007; Paquette, Fello & Jalongo, 2007, as cited in Chang, 2012).

Drawings alone are not always sufficient. It is important to engage in discussion with children about their drawings as a drawing may have a different meaning to the child than the educator (Chang, 2012). Discussing young children's drawing also helps with language development (Chang, 2012) and provides educators with a chance to model scientific vocabulary. Drawings can be a way to integrate monitoring into the teaching and learning of science concepts as a type of ongoing age-appropriate evaluation that allows children to demonstrate their ability to meet learning outcomes. Drawings can also be used to record the development of children's science skills and understandings over time.

Incorporate the use of stories

As with literacy and numeracy, narrative stories can be used to gain an understanding of children's science learnings. For example, one component of ScienceStart! (2018), a science program developed in the US for preschool children, is for educators to read stories about Curi the curious bear who encounters several problems (French, 2004). Children are prompted to suggest ways for Curi to solve the problems before the story continues, following the scientific reasoning structure of 'Reflect and Ask', 'Plan and Predict', 'Act and Observe', and 'Report and Reflect'. An example of a book used in the program to introduce the topic of colour mixing is Mouse Paint. The book provides the entry point to discussion and activities that are linked to the scientific reasoning structure. After completing a unit on colour mixing, children could indicate that Curi the bear could make all of the colours needed for a painting from the primary colours of red, yellow and blue. Children were able to transfer what they had learnt about colour mixing to other contexts (clothing colours) and to use sophisticated language ('primary colour').

Another example of narratives being used to monitor the development of young children's science understandings was in an intervention that aimed to shift preschool children from a focus on observing whether objects float or sink to considering the materials from which the objects were made (Kallery, 2015). Cartoons were used as a form of monitoring, with cartoon characters holding differing views about the phenomenon of floating and sinking. After undertaking floating and sinking activities, the children were able to judge each argument, express their own opinion and justify their view, providing evidence that they had developed conceptual understanding. Taking into account the material of an object was an important step towards the children's development of more sophisticated ideas about floating and sinking. Using stories or cartoons as part of monitoring young children's learning incorporates familiar formats and could make the monitoring process more engaging for them. The resource Concept cartoons as monitoring tools has activities to support this.

Use hands-on methods

Preschool science is 'all about hands-on activities', and therefore observation and evaluations should reflect this (Greenfield et al., 2009, p. 260). In a study of children aged four- to six-years, three dimensional (3D) models were constructed and used by children to show their understanding of the 'sphericity of the earth and the causes of the phenomenon of day and night' (Kallery, 2011, p. 341). Using 3D models in conjunction with childrens' verbal descriptions of what they knew about the sun and the Earth helped overcome the fact that some young children lacked the ability to explain what they knew without any concrete support. Using the 3D models helped the children show what they had learnt. Effective monitoring tasks need to provide children with the opportunity to apply the skills they have learnt and show what they know: using models is one way of supporting this.

Summary

Monitoring young children's science learning and understandings should provide an accurate picture of what children know and identify any gaps in their knowledge. Incorporating observations of young children's science abilities into documentation provided to parents would mean that such documentation could also be used to help educators plan science learning activities as well as provide evidence of what the children know and can do.

It is important that the monitoring focus is on science knowledge and skills and does not require children to be wholly dependent on literacy or mathematics skills. Monitoring activities should provide evidence that children have met the learning outcomes, but do not necessarily need to be separate activities, rather monitoring can be incorporated into sequences of science activities (Shepard, 2006 as cited in Chang, 2012).

There are various age-appropriate methods that can be used when designing and implementing science monitoring activities for young children, including drawings, checklists, discussions and educator observations. Monitoring should also reflect good early years practices.

Please refer to:

- Monitoring science understandings: Checklists for EYLF outcomes
- Monitoring science understandings: Checklists for AC Foundation – Year 2

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