Early science research summary: Use of play and role of the adult

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Abstract

The aim of this article is to provide an accessible summary of recent research into early science to support both early years and primary practitioners. Starting from the viewpoint of the child, rather than the subject of science, provides an early years perspective on science education. This summary draws on international research in both science and early childhood (up to age 7) to provide an introduction to key areas of debate in the use of play and the role of the adult. This short article cannot provide exhaustive coverage, but the aim of this summary is to bring together a range of work to provide a starting point for those seeking to consider research into early science.

Keywords: Early science, early years, early childhood, science education

Introduction

Science in the early years may not be explicitly called 'science', which is perhaps why those outside the sector may not be familiar with the research in this area. In fact, even those reviewing recent research into early childhood education and care note a paucity that refers to science or scientific enquiry (Rose & Gilbert, 2017). In England, early science has come under the spotlight, with primary science leads responding to a perceived push from Ofsted (2021) to track back lines of progression into the younger years, provoking questions about the dangers of 'backwash', rather than meeting the children's needs. There continue to be debates around purposes, whether the early years should be considered in terms of how it prepares for the next stage or how it supports the child's current rights and interests (Nutbrown, 2018).

Different starting points provide some explanation for the separation and lack of connection between phases: science education research usually starts with the *subject* of science, whilst early childhood research focuses on the *child*. The importance of the latter has become increasingly recognised, with research providing evidence for the significant impact of early childhood education and care on children's learning and life chances (e.g. Sylva *et al*, 2004). In addition, cognitive psychology provides insights into the capability of young children to build foundational concepts, learning from their early explorations of the world around them (e.g. Goswami, 2015).

It is proposed that an accessible summary of recent and international research into early science could support dialogue between early years practitioners and colleagues focused on science education. Relevant literature was initially located via a keyword search for *'early years/early childhood'* AND *'science'* since 2010 in both early childhood and science education international journals, together with identification of relevant reports (grey literature) and books available in the University library. Two areas of contention concern the role of play and the role of the adult, and it is these topics that will provide the focus for this research summary, after further consideration of the place of science in the early years. This short summary cannot provide exhaustive coverage and it is not a systematic review, but the aim is to bring together a range of work to provide a starting point for those seeking to consider research into early science.

Why consider science learning in the early years?

Science is both endemic and implicit in the early years. Young children learn through their interactions with their environment and such playful interactions are cross-curricular; they have no subject boundaries (Boorman & Rogers, 2000). Such interactions with the world are inherently scientific; the first step in any science enquiry is exploration or play (de Boo, 2000). As well as the *'specific area'* of *'Understanding the World'*, the statutory guidance for England lists three characteristics of effective teaching and learning: '*playing and exploring; active learning; creating and thinking critically'* (DfE, 2021:16), any of which could arguably apply to scientific exploration. Thus science can be found in every area of early childhood education.

Yet such a 'science is all around us' ethos may not be widely held, with some practitioners finding it difficult to see the science in their settings. A range of factors may be at play, including a view that science teaching methods have been developed for older children (Fleer, 2009), perhaps compounded by a lack of pedagogical confidence or even 'fear' of teaching science (Jones & Spicer, 2019).

In their evaluation of a STEM professional development programme for early childhood educators across Australia, MacDonald *et al* (2020) found that practitioner confidence was supported by recognition that science can be found in everyday experiences. Science is not something that only happens in laboratories, as one practitioner in the study noted: *'It's like simple things that you do every day… it's everywhere'* (p.360). Practitioner confidence can also be supported by understanding that, in developing the science process and way of thinking about the world, the adult is not expected to have an answer for every question that a child asks. Fleer (2009) argues that adult mediation is needed to build scientific learning through discourse with the child, which requires the practitioner to 'see the science' to be able to support the child.

In the US, Morgan *et al* (2016) found a strong correlation between low general knowledge in kindergarten and later low science attainment in elementary and middle schools, with the gaps between children from high and low socio-economic status widening. They argue that increased early opportunities for science could help to break this persistent cycle. Kähler *et al* (2020) in Germany found a similar pattern, that, for children from socially disadvantaged homes or those speaking a different language, initial differences in science in kindergarten persisted into primary school. However, they also found that attending a kindergarten where there was an explicit focus on science supported a positive impact on science learning, so argued that early promotion of science could help to reduce the disparities.

Early science is more than just preparation for later. Eshach and Fried (2005) identified a range of reasons to expose young children to science: enjoyment of engaging with nature; to develop positive attitudes and scientific thinking; to support later understanding through experience of phenomena and language; and that they are capable learners who *'can understand scientific concepts and reason scientifically'* (p.319). Larimore (2020) argues that early science education is a right for children and that they are entitled to *'make sense of their world for the joy and satisfaction it brings as well as the useful information it has for functioning in life'* (p.706). Campbell and Speldewinde (2018) similarly propose that young children's learning may be 'impoverished' without the opportunity to engage in science (p.38). If it is accepted that science learning can be an important part of early education, it is appropriate to next consider how to support such learning, which in this summary focuses on debates around the role of play and the role of the adult.

Debates about the role of play

We experience the world through our senses, combining multi-sensory information to develop our understanding (Goswami, 2015). Young children learn through their bodies and their senses (Boorman & Rogers, 2000). In fact, embodiment is relevant to all ages; as living bodies interacting with the material and social world, embodied cognition is a growing area for research (Kersting *et al*, 2021). Such direct experience through our senses is the starting place of scientific observation. Concrete sensory experiences help children to actively make sense of the world (Forrester *et al*, 2021). The exploration is led by the child, the playful infant has no constraint on time when they repeatedly put a rattle in their mouth or pour water between containers (de Boo, 2000). Such **playful exploration** is the precursor to scientific investigation (Johnston, 2010), the scientific method beginning with close observation.

Although, Campbell and Speldewinde (2018) note that there is a limit to sole discovery, with the role of the practitioner also being important in aiding understanding, as will be discussed in the next section.

The *Creative Little Scientists* project (2011-14) explored early science at 48 sites across nine European countries. They found that playful exploration was key for young children's learning in science, with the hands-on experiences supporting the children to make connections between their thinking and the environment. The ***'hands-on, minds-on exploratory engagement'*** (Cremin *et al*, 2010: 415) describes both the opportunity for the child to engage agentically in exploration of a range of resources, but also the opportunity for them to think about and discuss their ideas with others.

Early science provides the basis for **positive interests and attitudes** towards science, together with supporting a range of 'science-enabling' and 'science-specific' behaviours (Russell & McGuigan, 2016). Examples of 'science-enabling' behaviours include general logical skills such as classifying and ordering, which feature in both mathematical ordering of numbers and classifying vocabulary development in literacy, whilst more science-specific behaviours may be seen in early explorations or enquiries where children seek to answer questions and predict what might happen next. Skalstad and Munkebye (2021), in their study of outdoor learning in eight Norwegian settings, found that open exploratory activities led the children to move from asking practical questions related to task completion, on to higher level subject matter questions.

The adult has an important role in providing an enabling **environment,** which some describe as the third teacher (Grimmer, 2018). Forrester *et al* (2021) describe the importance of exposure to a diverse and rich environment. This includes open-ended materials, such as heuristic treasure baskets for babies or bags for toddlers (containing objects rather than 'toys'), or 'loose parts' construction materials for older children. Diverse and 'open' materials promote exploration and child agency (Cremin *et al,* 2015). Examples of practice can be seen in the Primary Science Teaching Trust (PSTT) 'Play Observe Ask' early years section of the website (see link below).

Outdoor experiences promote a wide range of learning and development, including exploration and possibility thinking (Rose & Gilbert, 2017). The use of outdoor spaces is an essential part of early years provision, particularly for science where, for example, the natural world supports development of biological concepts, 'messy play' supports the development of ideas about materials (early chemistry), and playground or vehicular play supports early physics. Davies and Hamilton (2018) note the prevalence of indoor adult-initiated teaching in response to accountability pressures in Wales and call for more recognition of the outdoor space as a place for learning. Campbell and Speldewinde (2020) propose that the bush kinder environment (Australian forest school) enables children to experience and improve their understanding of a range of science ideas: for example, with changes in weather over time enabling new insights to emerge. However, the scope of children's learning may be dependent on the educator's ability to scaffold their experiences and learning.

Sensory experience of the world leads children to develop **early scientific ideas**, for example*: naïve physics* ideas about the cause and effect of pushing or dropping; and the *naïve biological* ideas about moving and growing or the naming of categories of animal (Goswami, 2015). Such experience supports development of 'precursor models' of scientific concepts (Ravanis, 2020). Klofutar *et al* (2020) in Slovenia found that, whilst vicarious experiences of plants (from books etc.) can support observation and identification, direct experiences of forest organisms led to higher level and more persistent learning, since it enabled the children to use multiple senses at once, observing the trees holistically and linking the parts of a plant together.

Areljung and Sundberg (2018) note concerns regarding 'schoolification' and subject-based teaching, which may threaten the role of play and multi-dimensional teaching in pre-school pedagogy. They propose that the wide range of pre-school teaching dimensions such as fantasy, storytelling and sensory experiences should be used to support emergent science learning, which encapsulates both science concepts and methods. Pyle and Danniels (2017) propose a **continuum of child to adult-initiated play-based learning**, with one step up from 'free play' termed 'inquiry play'.

Inquiry play is child-initiated, but could include practitioner-scaffolded extension, for example, to support children to find out how far their paper planes had flown. Playful explorations could also feature further along the continuum in 'collaboratively designed play', co-designed with the children, and 'playful learning' adult-initiated activities. Whilst each of Pyle and Danniels' (2017) types of play could take place in a science context, they note the importance of an open practitioner viewpoint about the role of play, not to see 'play' and 'learning' as separate constructs, but to embrace a continuum of child- to adult-directed play, with opportunities for learning at each stage.

Debates about the role of the adult

The role of the adult is a much contested area in education, with a feeling that the practitioner needs to be all things to all people at all times. For example, Rose and Rogers (2012) describe the *plural practitioner*, with seven different dimensions that are integrated and interactive: critical reflector; carer; communicator; facilitator; observer; assessor; and creator (planning). It is through formative assessment, through sensitive and responsive scaffolding (Stylianidou *et al*, 2018), that the practitioner moves between these roles, co-constructing ideas in partnership with the children (Rose & Hattingh, 2014). Nutbrown (2018) prioritises **listening to the child**, arguing the importance of the child's voice and rights, as well as actively communicating with the family for an awareness of home-life experience. Such listening to young children's 'voices' can also include observing their actions, actively listening to what the child is 'saying' in their explorations (Nutbrown, 2018:30) and in their gesturing (Samuelsson, 2019).

Fleer (2009) argues that the child may not 'discover' scientific knowledge from just the provision of materials; **adult mediation** is important, supporting discourse and 'minds-on' activity. This suggests that there is an ongoing balancing act between listening to the child and mediating the learning. Rose and Rogers (2012) propose that adult- and child-initiated activities can *'co-exist in continuous interaction'* (p.71), perhaps a more 'meddling in the middle' approach (Craft *et al*, 2012). Stylianidou *et al* (2018) note the importance of opening up everyday learning activities so that there is space for children's decision-making and creative exploration. Part of the balancing act is also giving space and time for the children to explore at their own pace; incremental experience is crucial for learning and knowledge construction (Goswami, 2015).

The Oxfordshire Adult-Child Interaction project (2010-14) carried out action research with 18 practitioners, including paired discussions of video from 120 episodes to consider features of **effective interaction** (Fisher, 2016). For the interaction to be deemed effective, it needed to be a positive experience for the child and one where they gained something that they would not otherwise have had: the learning was enhanced by interaction with the practitioner (p.15). Such effective interactions are based on effective observation of the child, building a relationship and attuning to the individual, showing interest and getting to know their *'own personal cognitive jigsaw of the world'* (p.71). Scaffolding is seen to be responsive and fading, with the gradual transfer of responsibility over to the learner.

The **development of vocabulary** and scientific language is a key part of learning in the early years. Learning in young children is socially mediated (Goswami, 2015:24) and the role of dialogue is critical; it enables children to: *'externalise, share and develop their thinking, consolidate their ideas and develop verbal reasoning skills'* (Cremin *et al*, 2015:407). Using person-centred questions, such as 'What *do you think* will happen next?' (Harlen & Qualter, 2014), can open out discussions with children. Fisher (2016) emphasises the importance of 'wait time' when asking questions, both after raising a question and after hearing an answer, to give the child time to add more to their thinking (p.154).

The role of dialogue is further developed by considering the concept of **Sustained Shared Thinking,** where prolonged interaction includes exploring children's ideas and co-constructing ideas together (Siraj-Blatchford *et al*, 2002). The concept of Sustained Shared Thinking emerged from the Effective Provision of Pre-School Education (EPPE) longitudinal study, which followed 3000 children from ages 3 to 7, providing strongly evidenced recommendations about the importance of pre-school provision, especially for those from more disadvantaged backgrounds (Siraj-Blatchford *et al*, 2002; Sylva *et al,* 2004). 'Effective' settings (in general, not science-specific) were found to encourage open-ended questioning, Sustained Shared Thinking, modelling and an equal balance of adult/child-initiated activities. Science exploration could provide a context for episodes of Sustained Shared Thinking, whereby two or more individuals 'work together', for example, to talk through a problem, clarify an idea or evaluate an activity (Sylva *et al,* 2004). Although, Furman *et al* (2019) acknowledge that this is particularly challenging for less confident practitioners, noting that the 'driving force' in one setting was 'teacher talk' rather than 'true dialogues' and high numbers of 'unproductive' questions acted as 'noise' and were counterproductive to learning (p.283). The EPPE team also found that sustained dialogue did not happen frequently and, even in the most 'effective' settings, only 5.1% of questioning was open-ended (Siraj-Blatchford *et al,* 2002).

The adult has a key role to play in the **development of concepts**, for example, in expansion of children's vocabulary, which is fundamental to content knowledge (Guo *et al,* 2016). Whether describing children's early scientific ideas as 'naïve' science (Goswami, 2015), 'restricted conceptions' (Boorman & Rogers, 2000), preconceptions/ misconceptions (Kambouri-Danos *et al,* 2019) or 'working theories' (New Zealand Ministry of Education, 2017), the adult plays an integral role in supporting the development of language to explain such ideas. The adult can help to develop 'higher tier' vocabulary by modelling language use (e.g. see PLAN EYFS website link below) and playing in parallel with the child (Guo *et al,* 2016), for example in continuous provision areas like sand, water, construction or a 'mud kitchen'. Larimore (2020) argues that the most important content knowledge is that which comes from explorations and play-based experiences with phenomena that are part of children's daily lives, advocating a 'figuring out' rather than 'knowing about' list of content to cover. Although adult mediation remains integral, Fisher (2016) also notes the importance of consolidation, suggesting that practitioners should not feel that learners need to be constantly 'moved on' to their 'next steps', since they need time to practise, repeat, revisit and rehearse, as they assimilate such a huge amount of new information about how the world works into their current internal model (p.15).

Another contentious role is that of **documenting learning in science**. Digby (2014) argues that documentation should be more than a record of an event; it should support the learning process through active engagement of both practitioner and learner. New Zealand's Te Whāriki early childhood curriculum champions narrative learning stories, which involve families in a holistic process (Ministry of Education, 2017).

Russell and McGuigan (2016) argue that direct experience alone may not be enough to develop scientific conceptual understanding; they suggest that re-representing their experiences through drawing or speech develops a self-aware metacognitive dimension that supports learning. However, Areljung *et al* (2021) found that, despite pedagogical benefits of drawing to support understanding to become explicit, few of the thirteen Swedish practitioners in their study utilised drawing as a tool for communicating and learning science.

A function specific to science is that of **role model of positive attitudes** (de Boo, 2000), especially since there is often an uncertainty or lack of confidence around science in the early years (Forrester *et al,* 2021), with trainee-teacher research revealing their low science capital (Jones & Spicer, 2019). Campbell and Speldewinde (2018), in their study of bush kinder in Australia, found that the inclusion of science appeared to be dependent on the teachers' science understanding and philosophy of pedagogy.

They argued that building practitioner science knowledge would support the teacher to 'see' more science in the children's experiences and play, and so be able to integrate more science into bush kindergarten exploration. Avoiding a negative or gendered approach to science in the early years (Rippon, 2021), and including diverse representation of science, could help to build science capital, a feeling that 'science is for me', from an early age (Archer *et al,* 2020; Nag Chowdhuri *et al,* 2021). Crompton (2020) also highlights the importance of a child's context, proposing that we cannot make children interested in science, but need to take time to understand their interests and the 'funds of knowledge' that they bring (Chesworth, 2016).

In conclusion

The literature explored in this summary provides an argument for the importance of science in the early years, building foundational concepts, language and interest in the world. It is argued that early science can be seen as a form of playful exploration, with a 'hands-on, minds-on' approach providing shared experiences, especially for those from disadvantaged backgrounds, supported by dialogue with an interested adult. As noted at the outset, a short summary is only able to introduce the issues rather than fully explore the literature. Nevertheless, the breadth of research into science and early childhood presented above indicates that there is a range of studies and publications that can be utilised to inform practice and further research; it just may take a broader view of science in the early years to find them. The *Journal of Emergent Science* welcomes future articles in which to discuss the issues further and to present new insights and research.

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