

Science in Early Childhood

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Abstract

Much research has been published about children's science ideas and how to teach scientific phenomena and concepts to children in the upper primary and secondary schools. Research is now slowly growing with regards to the foundational knowledge and understanding of children at early childhood level and the role of teacher's subject content in providing authentic science learning experiences. This paper reviews the science education literature relating to early childhood education and the early years of primary school. It discusses children's foundational knowledge and understanding of science and teachers' professional knowledge of science and understanding of children's learning and development. It then examines the nature of teacher pedagogical content knowledge needed to provide quality and appropriate enriching learning experiences in the realm of science, and places this within Te Whaariki and other curriculum frameworks.

Introduction

Traditionally, the professional knowledge base of a teacher in training for the early education sector was seen as acquiring knowledge of child development and the pedagogy of how children learn (Cullen, 1999). Research has shown that, in contrast to Piaget's emphasis on domain-general structures and processes, children have specific knowledge and content, known as domain-specific knowledge (Cullen, 1999). This implies that children can now be viewed as having specific knowledge in various areas like literacy, science and mathematics. Gelman (1998, cited in Cullen 1999), believes that young children are able to make sense of their world by using categories and groupings. This is in line with Te Whaariki's (Ministry of Education, 1996) image of the child as a capable and competent learner. The acquisition of domain-specific knowledge is also referred to in the early childhood curriculum document, Te Whaariki, as one of the areas of development for children. (p. 21). This paper focusses

on the science domain-specific knowledge of children, and the science knowledge needs of teachers.

Children's domain-specific knowledge is unlikely to be acknowledged and extended if teachers are not confident in the knowledge themselves. It is doubtful that teacher's will be able to identify, analyse and extend children's scientific interests, if they are not comfortable with imparting the scientific knowledge themselves.

Children's foundational knowledge and understanding

Children's science views are a result of personal experiences, which include oral language interactions, watching television and reading books (Crabtree, 1982).

Interaction with family members and other adults also greatly influence children's ideas in their everyday understanding of science (Aram et al., 2001).

Historically, little attention was paid to young children's conceptions of science as it was thought that children could not understand scientific phenomena (Crabtree, 1982). However, later research has begun to accept children's views, labelling them 'children's ideas' (Osborne and Freyberg, 1985). Children come into a learning context with their own views and it is important for teachers to identify these views and to take them seriously (Harlen, 2001).

The conceptual language that children encounter may initially provide them with "unscientific" understandings. A typical example of this would be the consumption model of the electricity, where "it uses electricity" is a popular phrase that encourages alternative conceptions. According to Crabtree (1982) it is important for the learner to experience these alternative views, as they will be more able, through the teacher's supportive role, and through testing their ideas, to alter and modify their ideas to reach a more "scientific" understanding.

Richards (1996) believes that children can only take one point of view at a time, their own view. Crabtree (1982) suggests that the child's view is different to that of the adult. However, there are adults, particularly qualified early childhood teachers, who may have the same views as children, or their own alternative views. Harlen (2001)

contends teachers may not know when to introduce the scientific view of things or be able to do so in a way that the children will understand. She believes that some teachers also are reluctant to attempt scientific explanations, fearing that the children will not understand and will be left more confused. Consequently, children may be left with their own alternative ideas when they could actually be exploring and experimenting natural phenomena to develop their understanding. Harlen (2001) believes that other children are one of the most readily available sources of alternative ideas. In a context of play and collaboration, children may take on other children's suggestions, understandings and ideas.

Dunlop (1997) refers to Vosniadou's premise that it is important for children to understand why the scientific explanation is better than the common misconceptions that are encountered in every day experiences. The example Dunlop gives is of science teaching that the sun is a star, but in children's every day experiences the sun is associated with day and heat, whereas the stars are associated with night and cold. Contrary to this idea, Crabtree (1982) suggests never correcting a child's misconception and giving them the correct answers, but instead providing activities and learning experiences that will add to the child's understanding and development of the concept. "Explain only when they are ready. Under-explain rather than over-explain. A concept may take years to develop – there is no hurry. In fact, their thinking can't be accelerated, only encouraged" (p. 10).

Henriques (2000) looking at children's understandings of the weather in California found that the misconceptions held by the children were often very close to the truth. She cites as an example children's belief that water left out in a container changes into air. Technically, this 'misconception' is correct as water vapour is a legitimate component of air. Henriques expressed concern with the fact that most of the research of children's scientific ideas was concentrated in the physical sciences and not in the earth sciences. She observes that children have their own understanding of how the world works prior to receiving science instruction. Henriques stresses that these views need to be understood by the teacher in order to provide activities that may lead children to the correct scientific understanding. This is a valid point as long as the activities are appropriate. The children need to be at the level where their ideas can be

challenged and their interest sustained. For younger children, some activities may remain an activity of exploration and scientific enquiry.

Teacher's professional knowledge

Te Whaariki (Ministry of Education, 1996) was developed as a 'woven mat' for all to stand on, with the principles, strands and goals forming the framework. (Carr & May, 2000). It recognises the diversity of early childhood education in New Zealand, and allows for the various philosophies and cultures. It stresses that 'Children learn through responsive and reciprocal relationships with people, places, and things.' (Ministry of Education, 1996, p. 43). The holistic approach of Te Whaariki contrasts strongly with the subject-based approach of the New Zealand Curriculum Framework (Ministry of Education, 1993). Some concern has been expressed that focusing on an individual learning area like science may create a 'trickle down' effect and disrupt the holistic and integrated approach with which Te Whaariki is meant to be delivered (Carr & May, 2000).

However, right from the time Te Whaariki was introduced there have been claims that teachers need to have "teaching strategies and subject knowledge which allows them to extend children's foundational knowledge" (Cullen, 1996, p. 119). This view was endorsed in Farquhar's (2003) report on quality teaching in early childhood, which identified one of the seven characteristics of effective pedagogy that "effective teachers use content knowledge confidently to support and extend children's learning in interactive and play-based situations" (p 2).

A number of studies have addressed the need to develop teacher science knowledge. Haynes' (2000) research describes how the Auckland College of Education addressed the problem of insufficient subject knowledge for teachers through a dual-curricular approach and design of teacher programmes. Her study revealed that staff and students alike found that the dual-curricular approach enhanced the holistic nature of early childhood curriculum and the subject-based curriculum documents did not give prescription, but rather substance to the curriculum.

Dunlop (1997) also addresses the lack of teacher's subject knowledge, using evidence from a study in Finland in which 86 primary school teachers were asked to write an essay about factors affecting temperature differences on the earth. Only five teachers could give an accurate explanation. He suggests that this could be one of the critical factors of children's misconceptions, and stresses the importance of adults as student teachers acquiring the scientific knowledge, in order to plan and implement learning experiences that will lead children to an understanding of science concepts. As a result, Dunlop suggests a strategic plan to provide teachers with training in order to upskill their knowledge, and suggests various strategies for these to be achieved. Hedges (2004) also argues that beginning teachers cannot be expected to have all the knowledge, and that it is only through ongoing professional development that confidence in subject knowledge can be attained. Hedges (2004) also argues that in order to extend children's learning and knowledge, student teachers and teachers need to know the importance of, and how to access accurate science content, in order to promote knowledge and thinking of children.

Garbett (2003) puts forward a case of the importance of teacher's science content knowledge in order to provide stimulating and exciting science experiences for young children. Her study of student's teacher's science knowledge highlights that student's are not aware of how little they know, and her collection of results reveal that students scored the lowest in the Astronomy section. Garbett (2003) cites Alton-Lee & Praat's (2000) point that attitudes to science are generally stereotyped as a male subject and science was ranked as the subject in which they felt least confident. This supports the likelihood that the calibre of the student attracted to the early childhood sector is scientifically less knowledgeable than those attracted to primary and secondary teaching, where subjects are traditionally emphasised (Garbett, 2003).

Garbett stresses the importance of subject content knowledge of science as well as pedagogical content knowledge of how children may learn and develop scientific concepts and phenomena, where the one is dependent on the other (Garbett, 2003). This implies that the teacher may know how to interact with the young child in gaining an understanding of a science concept, but a limitation of the understanding of the science concept at hand will restrict the teacher from asking meaningful questions

and extending the child's thoughts. Davis (2003) also believes that subject knowledge in itself is not sufficient for effective teaching. She advocates for science content knowledge that joins pedagogical content knowledge. In her study, she describes the knowledge integration model as an attempt to strengthen student teacher's subject and pedagogical content base for effective teaching in the United States.

The move away from a Piagetian developmental based pedagogy to a more pro-active Vygotskian based socio-cultural approach has seen a change in the role of the teacher to one of providing guidance, support, direction, challenge and impetus (New, 1998). As a result it has become imperative that teachers have the subject knowledge to deal with the knowledge that children bring to a learning environment.

Science in the assessment, planning and evaluation of the programme

Hadzigeorgiou (2001) argues that scientific experiences need to be designed in order to stimulate wonder, as wonder gives things their meaning and reveals their significance. He terms this, 'intellectual curiosity' (p.2), and argues that scientific knowledge cannot only be built through 'pedagogically appropriate activities', but needs to have the element of intellectual curiosity. Water, light, sound and force are topics that incite wonder and amazement through hands-on activities, but it requires informed use of teacher's subject knowledge to bring about learning of scientific concepts. This "scientific attitude" is also highlighted in the early childhood curriculum, Te Whaariki as the disposition of curiosity in the strand of Belonging.

This approach can be contrasted with a content orientated adult-initiated curriculum which ignores learning and developmental processes (Tinworth, 1997). Tinworth points out that themes chosen by teachers may not allow for children's interests to be followed and that this makes teachers less responsive to the depth and pace of learning of individual children. She argues for a child-initiated curriculum in which children are empowered and take responsibility for their own learning when their ideas, interests and enthusiasm are shared and valued by teachers (p. 28).

Much of the research literature on teaching and learning of science in early childhood settings reinforces the need for a socio-constructive pedagogy. Fleer's (1991) study

focussed on the children's knowledge of an electrical circuit, their knowledge of how a torch operates and how electricity flowed through a circuit. Through factual books and modelling, the children were moved towards scientific understandings. The close collaborative relationship of teacher and child that developed led Fleer to "science learning in early childhood is better placed within a paradigm in which learning is viewed as being socially constructed" (p.97). Smith (1996) also found that the child can be moved forward to another level by working in the child's ZPD.

French (2004) speaks of an adult's guidance to enrich children's learning in a way that paces activities, creates a language-rich environment, and scaffolds children's learning. She attests to the fact that science fits well into early childhood programmes as it is a soundboard to children's inherent curiosity and natural enquiring minds. Ordinary activities can become scientific events for children by engaging with mixing paints, pressing a boat into water or watching a worm crawl through the mud. These experiences provide opportunities for hands-on, practical interaction, accompanied by the use of language, which aids intellectual development and language acquisition. French also mentions that children construct knowledge through observing, predicting, planning, asking questions and reflecting on the experiences.

After careful assessment of children's authentic interests, the project approach is an appropriate way to introduce and encourage extended learning on a science topic. Stegelin (2003) attests to the fact that project work should be mostly initiated by the children's interests with the role of the teacher being one of facilitator and guide. She emphasises the importance of documentation both as an evaluation tool and a means of developing the emerging ideas of the children.

Educational trips can extend on children's learning about a topic, allowing them to experience scientific phenomena first-hand, and revisit concepts, thereby strengthening their knowledge base. Hedges (2004) describes a visit related to children's interest in marine biology. She illustrates how children's authentic interests can be taken seriously and reflected in an integrated curriculum. Prior to the visit to the aquarium, the programme included story books and non-fiction books about the ocean, children drawing different ocean creatures and viewing a real diving suit and

its accessories. Following the excursion, more follow-up activities were available, including a shark video and a dramatic play corner. Water play with plastic ocean animals was available for children to re-enact their experiences.

Conclusion

This review has highlighted the importance of teacher's subject knowledge in science in order to ascertain, add to and alter children's foundational science knowledge. The importance of a socio-culturally based pedagogy is also clear. Research has shown how children's thinking can be moved a step forward, through the help of a more skilful partner. This can only be attained if the more skilful partner is armoured with the knowledge. Using and building on children's interest, curiosity and exploration, allows the teacher to enhance their understanding of scientific concepts within a play-based curriculum.

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