Teaching Science During the Early Childhood Years

by Dr. Kathy Cabe Trundle

IF YOU HAVE EVER WATCHED A YOUNG CHILD collect rocks or dig in the soil looking for worms you probably recognize children have a natural tendency to enjoy experiences in nature. Young children actively engage with their environment to develop fundamental understandings of the phenomena they are observing and experiencing. They also build essential science process skills such as observing, classifying, and sorting (Eshach & Fried, 2005; Platz, 2004). These basic scientific concepts and science process skills begin to develop as early as infancy, with the sophistication of children's competency developing with age (Meyer, Wardrop & Hastings, 1992; Piaget & Inhelder, 2000).

The Importance of Science in Early Childhood Education

Research studies in developmental and cognitive psychology indicate that environmental effects are important during the early years of development, and the lack of needed stimuli may result in a child's development not reaching its full potential (Hadzigeorgiou, 2002). Thus, science education in early childhood is of great importance to many aspects of a child's development, and researchers suggest science education should begin during the early years of schooling (Eshach & Fried, 2005; Watters, Diezmann, Grieshaber, & Davis, 2000).

There are several reasons to start teaching science during the early childhood period. First, children have a natural tendency to enjoy observing and thinking about nature (Eshach & Fried, 2005; Ramey-Gassert, 1997). Young children are motivated to explore the world around them, and early science experiences can capitalize on this inclination (French, 2004). Developmentally appropriate engagement, with quality science learning experiences, is vital to help children understand the world, collect and organize information, apply and test ideas, and develop positive attitudes toward science (Eshach & Fried, 2005). Quality science learning experiences provide a solid foundation for the subsequent development of scientific concepts children will encounter throughout their academic lives (Eshach & Fried, 2005; Gilbert, Osborne, & Fenshama, 1982). This foundation helps students to construct understanding of key science concepts and allows for future learning of more abstract ideas (Reynolds & Walberg, 1991).

Engaging science experiences allow for the development of scientific thinking (Eshach & Fried, 2005; Ravanis & Bagakis, 1998). Supporting children as they develop scientific thinking during the early childhood years can lead children to easily transfer their thinking skills to other academic domains which may support their academic achievement and their sense of self-efficacy (Kuhn & Pearsall, 2000; Kuhn & Schauble, & Garcia-Milla, 1992).

Early childhood science learning also is important in addressing achievement gaps in science performance. Although achievement gaps in science have slowly narrowed, they still persist across grade levels and time with respect to race/ethnicity, socioeconomic status (SES), and gender (Campbell, Hombo, & Mazzeo, 2000; Lee, 2005; O'Sullivan, Lauko, Grigg, Qian, & Zhang, 2003; Rodriguez, 1998). Lee (2005) describes achievement gaps in science as "alarmingly congruent over time and across studies" (p 435), and these achievement gaps are evident at the very start of school. Gaps in enrollment for science courses, college majors, and career choices also persist across racial/ethnic groups, SES, and gender (National Science Foundation, 2001, 2002). Scholars have linked early difficulties in school science with students' decisions to not pursue advanced degrees and careers in science (Mbamalu, 2001).

Science education reform efforts call for "science for all students" to bridge the science achievement gaps. Yet attainment of this goal has been impeded by a lack of systematic instructional frameworks in early childhood science, insufficient curricula not linked to standards, and inadequate teacher resources (Oakes, 1990). Poor science instruction in early childhood contributes to negative student attitudes and performance, and these problems persist into the middle and high school years (Mullis & Jenkins, 1988). Eshach and Fried (2005) suggest positive early science experiences help children develop scientific concepts and reasoning, positive attitudes toward science, and a better foundation for scientific concepts to be studied later in their education.

Young Children's Early Ideas about Science

In order to help children learn and understand science concepts, we must first understand the nature of their ideas about the world around them. A number of factors influence children's conceptions of natural phenomena. Duit and Treagust (1995) suggest that children's conceptions stem from and are deeply rooted in daily experiences, which are helpful and valuable in the child's daily life context. However, children's conceptions often are not scientific and these nonscientific ideas are called "alternative conceptions." Duit and Treagust proposed six possible sources for alternative conceptions: sensory experience, language experience, cultural background, peer groups, mass media, and even science instruction.

The nature of children's ideas, the way they think about the natural world, also influences their understanding of scientific concepts. Children tend to view things from a self-centered or human-centered point of view. Thus, they often attribute human characteristics, such as feelings, will or purpose, to objects and phenomena (Piaget, 1972; Bell, 1993). For example, some children believe the moon phases change because the moon gets tired. When the moon is not tired, we see a full moon. Then, as the moon tires, we see less of the moon.

Children's thinking seems to be perceptually dominated and limited in focus. For example, children usually focus on change rather than steady-state situations, which make it difficult for them to recognize patterns on their own without the help of an adult or more knowledgeable peer (Driver, Guesne, & Tiberghien, 1985; Inagaki, 1992). For example, when children observe mealworms over time they easily recognize how the mealworms' bodies change from worm-like, to alien-like, to bug-like (larva to pupa to adult beetle). However, they have difficulty noticing that the population count remains constant throughout the weeks of observation.

Children's concepts are mostly undifferentiated. That is, children sometimes use labels for concepts in broader or narrower ways that have different meanings than those used by scientists (Driver et al, 1985; Inagaki, 1992).

Children may slip from one meaning to another without being aware of the differences in meaning, i.e., children use the concept labels of living and non-living differently than do adults or scientists. For example, plants are not living things to some young children because they do not move. However, the same children consider some non-living things, such as clouds, to be living things because they appear to move in the sky. Finally, children's ideas and the applications of their ideas may depend on the context in which they are used (Bar & Galili, 1994; Driver et al., 1985).

Children's ideas are mostly stable. Even after being formally taught in classrooms, children often do not change their ideas despite a teacher's attempts to challenge the ideas by offering counter-evidence. Children may ignore counter-evidence or interpret the evidence in terms of their prior ideas (Russell & Watt, 1990; Schneps & Sadler, 2003).

Effectively Teaching Children Science

Contemporary instructional approaches described in science education literature draw heavily on the constructivist philosophy. Although there are many forms of constructivism, all of the instructional applications of constructivism view children as active agents in their personal construction of new knowledge (Fosnot, 1996; Gunstone, 2000). Further, these instructional approaches aim to promote active learning through the use of hands-on activities with small groups and with sense-making discussions. A common expectation is that learners are more likely to construct an understanding of science content in this type of inquiry-based learning environment (Trundle, Atwood, Christopher, & Sackes, in press).

However, minimally guided instructional approaches, which place a heavy burden on learners' cognitive processing, tend to not be effective with young children. A heavy cognitive burden leaves little capacity for the child to process novel information, thus hindering learning (Kirschner, Sweller & Clark, 2006; Mayer, 2004). As educators consider young children's limited cognitive processing capacities, inquiry-based instructional approaches, which are guided by the teacher, seem to offer the most effective way for young children to engage with and learn science concepts.

A guided, inquiry-based approach allows for scaffolding of new scientific concepts with the learner's existing mental models (Trundle et al., in press). In a guided, inquiry approach, children are expected to be active agents in the learning activities, which strengthens children's sense of ownership in their work and enhances their motivation. With this approach, children usually work in small groups, which promotes their collaboration skills and provides opportunities to scaffold their peers' understandings. Meaningful science activities, which are relevant to children's daily lives, allow children to make connections between what they already know and what they are learning. Sense-making discussions promote children's awareness of the learning and concept development and facilitate the restructuring of alternative ideas into scientific mental models.

As teachers work with children to develop their inquiry skills, the instructional strategies should move toward more open inquiry where children are posing their own questions and designing their own investigations (Banchi & Bell, 2008).

Integrating Text with Inquiry Learning

- Traditional science instruction has unsuccessfully relied heavily on didactic, textbook-based approaches. A growing body of literature suggests that traditional, text-based instruction is not effective for teaching science because children are usually involved in limited ways as passive recipients of knowledge. However, nonfiction, expository text can be integrated effectively into inquiry-based instruction. Researchers suggest that the use of expository text should be accompanied with appropriate instructional strategies (Norris et al., 2008). Teachers should ask questions that activate students' prior knowledge, focus their attention, and invite them to make predictions, before, during, and after reading the expository text. These types of questions promote children's comprehension of the text and improve science learning (Kinniburgh, & Shaw, 2009).
- The structure of the text can affect science learning. The main ideas in the text should be supported with several examples, and these examples serve as cognitive support for the children. Examples should be highly relevant to the main idea so children can establish connections between the text content and their own personal experiences (Beishuizen et al., 2003).
- Diagrams also support science learning. Effective, clear diagrams that represent causal relationships in the text support children's comprehension of causal mechanisms (McCrudden, Schraw, & Lehman, 2009).
- Illustrations and images in textbooks can be effectively integrated into inquiry-based instruction. Learning by inquiry involves, among other skills, observation in nature over time. However, teachers are presented with several challenges when they try to teach science concepts through actual observations in nature. For example, some phenomena are not observable during school hours. Weather conditions and tall buildings or trees can make the observations of the sky difficult and frustrating, especially for young children. Also, observations in nature can be time consuming for classroom teachers who want to teach science more effectively through an inquiry approach. Images can be used to allow children to make observations and inferences. Teachers also can have children compare observations in nature to illustrations and images in books. While many science educators might argue that observing phenomena in nature is important, the use of illustrations and images in the classroom offers a practical and effective way to introduce and teach science concepts with young children (Trundle & Sackes, 2008).

Conclusion

Young children need quality science experiences during their early childhood years. *Science and Literacy* provides a systematic, instructional framework, a standards-based curriculum, and high quality teacher resources. This program also effectively integrates text, illustrations, and diagrams into inquiry-based instruction.

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