Supporting the **Scientific Thinking** and **Inquiry** of Toddlers and Preschoolers through **Play**

Maria Hamlin and
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Some educators have reservations about teaching science in early childhood settings. They might lack confidence in their own scientific knowledge or wonder how to include more science content in their teaching. As a science methods instructor, Maria frequently hears from her students, "I'm not really very good at science. I had to take a few science courses along the way, but I don't really know how to include more science in children's everyday learning."

An early childhood teacher educator, Debora has spent many years examining the educational potential of children's play with preservice and inservice teachers. She has found that many teachers recognize the importance of play in learning but struggle with how play activities connect with content knowledge and how they should support children's learning though play. Through our conversations, the two of us have found points of agreement and opportunities to grow from each other's perspective.

Whether smelling the air, tasting a flower's nectar, feeling the texture of a smooth rock, rolling a toy car down an incline, building a tower, or looking at a cicada shell, children have been learning since birth. Children learn about the world by using their senses. When healthy children are born into the world, they breathe and taste the air, they feel the coolness of air in contrast to the warmth of the womb, they hear familiar voices and see people associated with those voices. Through observation they begin to make connections related to their environment, thus creating knowledge.

Many of these activities and opportunities for sense-making occur through play. Play provides abundant opportunities for children to learn science concepts such as the diversity and interdependence of life, relationships between force and motion, and the structure of matter. It is also a rich context in which to introduce young children to the process of scientific inquiry.

Teachers support play through intentional planning and engaging in high-quality interactions with children and adults. For example, to provide opportunities for children to learn about force and motion, teachers could encourage children to discover what happens when they touch and move objects made of different materials, like wooden cars or plastic tubes. The teacher also shares the experience with the children by observing and commenting on their actions and asking "What if?" questions. This planning and interaction leads to ever-increasing knowledge and understanding of force and motion. In the following sections we share how one family child care provider created opportunities for children ages 18 months to 3 years to make connections between different types of play and science learning. We

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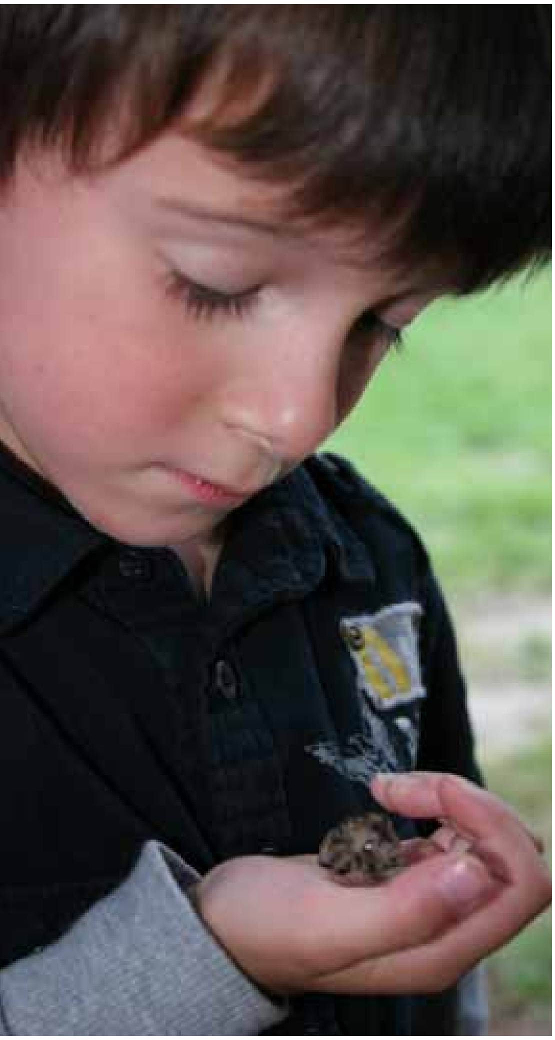
offer explanations and examples of how teachers can create opportunities for young children to expand their understandings of scientific concepts and science inquiry during play.

Learning through play

> It is paradoxical that many educators and parents still differentiate between a time for learning and a time for play without seeing the vital connection between them.
>
> —*Leo F. Buscaglia*

Understanding the different ways children play and how they think during different play activities is relevant to understanding how teachers can support scientific concept development through play. Diane teaches infants to 4-year-old children in an urban family child care home in the Midwest. She observes the children playing with cicada shells (molted exoskeletons of cicada nymphs) in the play yard. Diane attempts to provide experiences that build on the children's different types of play and their thinking about cicada shells.



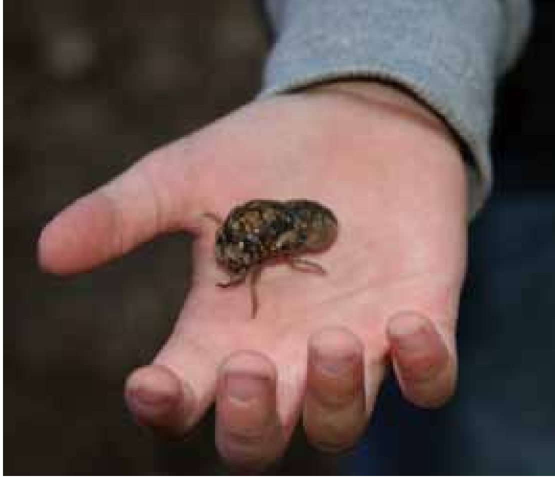
Courtesy of the authors

Functional or discovery play (exploring and using the senses)

One summer day Diane noticed that the children had discovered a cicada shell stuck to the bark of a tree in the play yard. The children touched and felt the shell with their fingers, holding it gently in their hands. One of the younger children squeezed the shell and quickly found out it was fragile and could be crushed. They looked closely at the shell and noticed it caught on the skin of their hands. They tried hooking it on other objects in the yard to see if it would stick, as it did on the bark. They found a few more cicada shells on the tree.

Their initial play sparked a question: Was the shell dead or alive? Rather than answer their question directly, Diane asked the children: Can it eat? Does it move? Does it grow? The children decided the shell was not alive, but now they wanted more shells.

Over the next several weeks during outdoor playtime, the children collected more shells. They looked for both living cicada nymphs and nonliving cicada shells. Diane mounted the shells on index cards, labeling them with terms like *exoskeleton* and *nymph.* The children observed the shells under a microscope. They went to the local library and checked out nonfiction books about cicadas.



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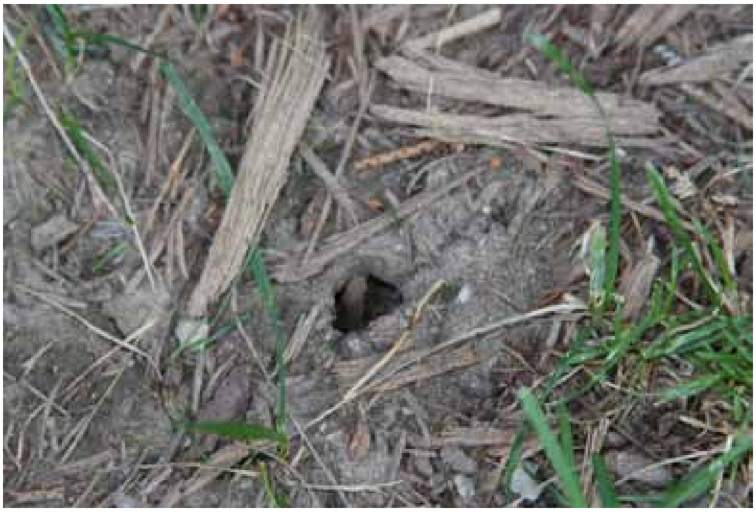
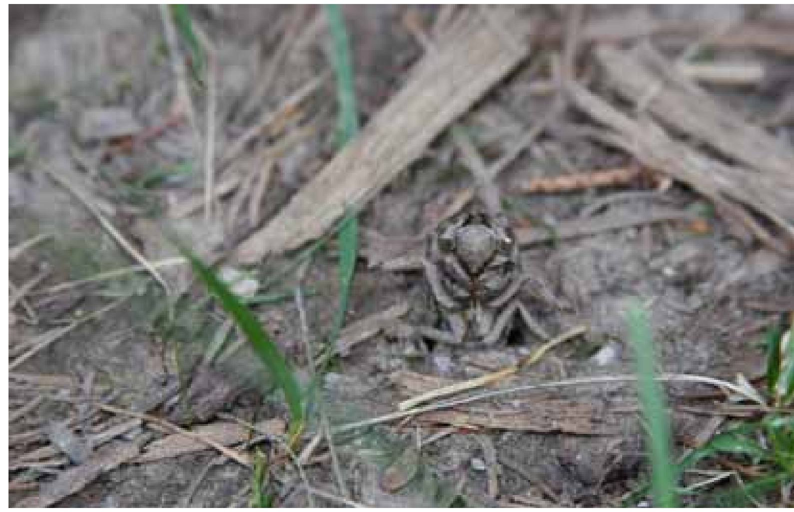
Symbolic play (using objects and language to represent ideas)

The children learned more about cicadas. They painted and drew pictures of cicada nymphs, their shells, and adult cicadas and displayed the pictures in the family child care home. They pretended to be scientists during outdoor playtime, as they gathered more shells. One day, they found cicada nymphs molting and observed an adult cicada emerge from a shell. Once the cicada emerged, they sang "Happy Birthday."

To duplicate the action of the newly emerged cicada unrolling its wings, Diane carefully folded and rolled up green tissue paper, placed it into an empty toilet paper roll and let the children pull out the paper and unroll and unfold it to model the process they had observed in the cicada. She encouraged the children to look for cicada nymphs getting ready to molt, and she made a video of the transformation from nymph to adult. While watching the video, the children described what they saw. Diane continued to read books aloud to the children and help them label their drawings.

Teachers can create opportunities for young children to expand their understandings of scientific concepts and science inquiry during play.





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Games with rules (organizing games with rules and roles)

Once the older children understood that cicadas have different stages of development, they modified their role play to create a game called Cicada Patrol. The children added rules or challenges, such as, “Who can find the most shells?” and “Who can find cicadas at their different life stages?” The children kept track of their findings, which led them to try to figure out where the cicada nymphs came from, thus increasing their “scores.” The children noticed that the cicada shells were “dirty” and remembered that one of the books indicated the nymphs lived underground. They then began to notice holes in the ground by the tree where they had found a number of cicada shells. Diane continued to encourage the children to use observation, a science process skill, to find the most cicadas during Cicada Patrol.

As demonstrated through these scenarios, in each type of play the children think in qualitatively different ways. In functional play, the children hunted for cicada shells. They repeated actions over and over, with no predetermined purpose. They were coming to understand the qualities of physical objects and observe the effects of their actions on objects. In symbolic play, the children drew cicadas and pretended to be scientists. They used language to describe what they were thinking as they purposefully constructed representations of objects or actions with materials or through pretend play. Playing games with rules, the children created the Cicada Patrol. They applied more rules to their activities, and they planned and strategized in more complex ways (Frost, Wortham, & Reifel 2007). Yet, while each type of play experience was qualitatively different, what each had in common is that the children were thinking, reasoning, trying to use logic, and searching for relationships between events. This type of play is often referred to as cognitive play or play as cognitive development.

The key to high-quality teaching is to gear activities to children’s progressively more complex approaches to understanding the world. Early childhood educators and researchers recognize that “play provides an intrinsically motivating context in which children come together to understand their world” (Drew et al. 2008, 40). However, educators and researchers also recognize that for teachers to enhance the learning potential within play contexts, they must observe the children’s thinking, understand the potential of learning content through use of different materials, and demonstrate playfulness and openness to wonder and possibility. The following sections explain how teachers can understand and build on young children’s scientific thinking.

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Thinking like a scientist

> When I was a kid I had a lab. It wasn’t a laboratory in the sense that I would measure and do important experiments. Instead, I would play.
>
> —*Richard Feynman,* Nobel Prize Recipient in Physics

The National Science Education Standards (NRC 1996) state that “scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world” (23). Inquiry is an active process that requires many different skills. These skills are often referred to as scientific process skills and include

- observing;
- asking questions;
- describing;
- predicting;
- providing explanations;
- using tools and instruments to extend the senses and improve observations;
- engaging in "what if" investigations;
- planning investigations;
- recording what happens during these investigations;
- interpreting; and
- communicating and sharing ideas.

These are all skills that young learners can develop when they are supported by adults. The process of scientific inquiry uses these skills and requires children to participate in a cyclical process in which they use process skills in a variety of ways. For example, a child might be playing with a magnet and observe that it attracts an object composed of plastic and metal. She might then wonder what part of the object is magnetic. She then may begin to test a variety of objects made only of plastic, interpret her data, and conclude that only the metal portion of the original object is magnetic.

Many of the skills and habits of scientific thinking are inherently part of children's play.

While the complete scientific inquiry process, which requires multiple cycles of investigation, may not be part of a child's play episode, we believe that many of the skills and habits of scientific thinking are inherently part of children's play. In the next section we explain in more detail how children's thinking develops in relation to scientific concepts.

Children's thinking: From everyday concepts to scientific concepts

> The whole of science is nothing more than a refinement of everyday thinking.
>
> —*Albert Einstein*

As children's play experiences change as children grow, so does their concept development. Teachers can document the changes in children's understandings of scientific concepts while observing their play (Fleer 2008). Vygotsky (1962/1986) made a distinction between *everyday,* or spontaneous, concepts and *scientific* concepts. Children develop everyday concepts intuitively through interactions in everyday experiences (such as play). These concepts are embedded in the contexts in which they are developed; for example, when a child plays at a water table and experiences the properties of water as a liquid. *Scientific* concepts are concepts children learn in school. These concepts are based on the structured thinking, logic, and language used in the discipline of science and developed through interactions with a teacher; for example, a child learning about volume. Often, these concepts are taught outside of the context in which children are developing everyday concepts. Bedrova and Leong (1996/2007) describe the interplay between everyday concepts and scientific concepts as follows:

> Children will not understand concepts such as "volume" if they do not have everyday concepts of "liquids" and "measuring." The scientific concept directly depends on the child's everyday understandings of the world. As children learn scientific concepts, the meaning of liquids and measuring changes. It is a two-way process—scientific and everyday concepts grow into one another. The scientific concept is modified by the everyday concept, and the everyday concept is changed by the learning of the scientific concept. (60)

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In the following play episodes, a young child develops everyday concepts through play, with the support of his mother.

About to clean some cabinet hardware with baking soda and vinegar, I called my son Mateo, who is 3, into the kitchen to observe the chemical reaction. I showed him the baking soda and let him smell the vinegar, then I asked him some questions about the properties of the vinegar and baking soda. He responded that the baking soda was a powder and it was dry, and the vinegar was wet. Since he had witnessed other chemical reactions, I asked him to "predict" what might happen when I poured the vinegar on top of the white powder. He replied, "I don't know, Momma. Maybe it will get wet." I poured the vinegar over the baking soda. As the mixture bubbled, my son exclaimed, "You made soap!" I asked him why he thought it was soap. He told me to "look at the bubbles."

Later that afternoon Mateo asked for a cup of seltzer water. I poured him a small cupful, and he walked into the living room. There was a long silence, and I decided to investigate. I saw Mateo sitting at the coffee table with his cup of seltzer and a container of powdered Gatorade. I watched him take two scoops of Gatorade and add them to the seltzer water. It fizzed. I asked, "What are you doing?" Mateo responded, "Look, Momma, I'm being a scientist–momma. I'm mixing like a scientist." I asked him what happened when he mixed the Gatorade with the seltzer. He explained what had occurred and what he had observed: "I mixed this, and this bubble water. It made bubbles. Not big bubbles, little bubbles."

In this story, we see a mother encourage her son to use his prior knowledge to *wonder* about the materials and to *notice* what is happening. These are the first steps in the scientific inquiry process. Mateo expresses his everyday concept of soap—where there are bubbles, there is soap. Furthermore, this interchange sparked pretend play. He pretends to be a "scientist–momma" (his mother is a scientist), expands his experiences using similar materials, pretends to investigate, and explores his understanding of what it means to be a scientist. He also identifies himself as a scientist when he says he is "mixing like a scientist." Finally, his mother returns his thinking to the inquiry process by asking him what happened.

In essence, the mother's questions ask her son to report on the data he observed in his own pretend science experiment. The parent in this situation sparked a theme for play, validated and expanded on the pretend play, and modeled parts of the scientific inquiry process. This is just one example of how adults support children's scientific thinking through play. There are many ways early childhood educators support scientific thinking by keeping in mind the aspects of the scientific inquiry process.

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Teachers supporting scientific play

How can teachers use play as opportunities to engage young learners in scientific inquiry? The key is in the types of experiences teachers create for young learners and how they support children during "science play" (Commonwealth of Australia 2009/2012) experiences. When teachers create science-play experiences, it is important for them to consider three things: the types of materials to provide; the questions to pose prior to, during, and after children's exploratory play; and what additional explorations could further children's science learning opportunities.

Types of materials

To support an inquiry about force and motion, teachers can choose from many materials, including toy vehicles, balls and ramps, construction sets, and marble runs. Each of

As children finish their play, the teacher can ask questions to help them summarize their understanding and share their discoveries with one another.

these materials affords different learning experiences for the children and different opportunities to engage in scientific inquiry. For example, playing with toy dump trucks on an inclined ramp allows children to change loads and determine how far the truck travels, leading to an opportunity to determine the relationship between mass, momentum, and acceleration.

Questions to pose

In addition to thinking about materials, teachers also consider questions to ask. Suppose the children are running their cars on a flat surface. A teacher may begin a science-play experience by asking such questions as: How can you make the car go fast? How can you make the car go slow? These types of questions help guide the children's play. A teacher can ask: How are you making the car move? What do you do to make the car go fast or slow? What did you do differently that time? These questions help the children focus their observations as well as ask additional questions that interest them at this point or that they might want to pursue later. As children finish their play, the teacher can ask questions to help them summarize their understanding and share their discoveries with one another. When children have an opportunity to communicate their ideas and hear other perspectives from their peers, they are better able to identify patterns and formulate relationships about the data.

Additional explorations

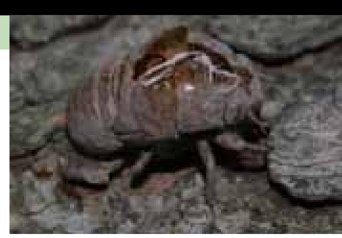
After this initial science-play activity, teachers can conduct additional experiences for the children, using other materials or using the same materials in a different way. For example, children could roll similar cars down a ramp. The cars might have different amounts of mass, such as round ceramic magnets, added to them. The children can then begin to answer the question, "Does mass affect the motion of the car?" This is a focused exploration that leads to other focused observations. These cycles of science play are integrated with the process of inquiry. Science play lays a foundation for the scientific inquiry that occurs in the primary grades, when everyday concepts are increasingly integrated with scientific concepts.

The table "Young Children's Play" introduces a variety of science-play experiences and shows their relationships to everyday concepts and scientific concepts. For each experience, we provide questions teachers can ask to guide children's scientific inquiry.

Young Children's Play:

Developing from Everyday to Scientific Concepts

Materials	Science-play experience	Everyday concepts	Scientific concepts	Teachers' questions
Cars and trucks	Rolling cars and trucks across the floor.	Pushing the truck makes it move.	The greater the force applied to an object, the greater the distance an object will travel.	How can you make the truck travel the longest distance? How can you make the truck travel the shortest distance?
Ramps and balls	Creating a ball run and trying to increase and decrease the speed of the ball.	Balls roll down ramps.	The steeper the incline, the faster the ball will move. The steeper the incline, the more energy the ball has as it rolls.	How can you make the ball go faster? Slower?
Density bottles—4 or 5 similar bottles with different volumes of water—and a tub of water	Predicting which bottles will float and which will sink. Making a density bottle that stays below the water's surface without sinking to the bottom.	Heavy objects sink and light objects float.	Objects with higher density tend to sink, and objects with lower density tend to float.	Which bottles sink? Which bottles float? Can you make a bottle that hangs in between?
Magnifying glass	Completing a scavenger hunt with a magnifying glass.	A magnifying glass makes things look bigger.	A magnifying glass is a scientific tool that increases the sense of sight.	What did you see with the magnifying glass that you couldn't see with just your eyes?
Hand shadows and a light source	Telling a shadow story.	Hands can make shadows.	Shadows are caused by solid, opaque objects that interrupt the path of light.	Can you make the shadow bigger? Can you make the shadow smaller?



Conclusion

Play offers a rich context for children to engage in elements of scientific inquiry. Children naturally use their everyday understanding to make sense of their play experiences. In the case of science-play experiences, teachers use their knowledge and understanding of both the content and how children make meaning during play. This knowledge helps teachers guide children's play experiences and engage children in additional science-play experiences that lead to further inquiry.

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