Tips for helping children do science

by Carol Armga, Sandi Dillon, Mary Jamsek, P.D. Jolley, Elizabeth L. Morgan, Diana Peyton, and Hallie Speranza

A 3-year-old picks up a green leaf off a mound of otherwise brown and red leaves piled at the base of an almost leafless tree. He turns the leaf over, top to bottom and bottom to top, and says, "Poor guy, he didn't have a chance to turn red."

A 4-year-old watches a handful of cornmeal as it slowly falls between his fingers. He observes, "Cornmeal smells like warm bodies."

A 3-year-old points to a pile of brown leaves that had blown into the far corner of the porch. She asks, "How did the leaves get there?"

We may smile at these comments, but they reveal something important. Children are continually observing, questioning, and describing the things in their world. They are identifying, comparing one thing to another, and communicating their discoveries. They are doing science.

The term *science* strikes fear into the hearts of many early childhood teachers. For example, Ms. Okama remembers her grade school science experiences—memorizing the names of planets and being quizzed on the characteristics of different rocks.

Filled with doubt, she thinks, "I can't teach science to young children."

Inexperienced teachers sometimes make the mistake of presenting science as magic. For example, Ms. Black, shows children how to put out a lighted votive candle by turning a glass upside down over it. "There, it's out." she says, without letting the children discover that fire needs air to burn, measuring how long it takes to go out, or using different sizes of glasses to extinguish the flame.

Science doesn't need to be scary or magical. A first step in reducing science-teaching anxiety and making science real is to redefine it. What is science? Improved understanding draws us to the next steps. What do we need to think about when planning science activities? How can we promote scientific thinking? How can we extend science to other areas of the classroom?

What is science?

For a young child, science is discovery. The word *discovery* evokes an image of children using all five senses—sight, hearing, touch, taste, and smell—to actively explore their surroundings.

> "I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary whilst the great ocean of truth lay all undiscovered before me."
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> —*Isaac Newton*

Science in early childhood settings refers to everything young children experience with their senses. Teachers guide children to integrate these experiences into cognitive concepts. Cognitive concepts are ideas about people, places, events, objects and animals that children encounter in their everyday lives.

Jean Piaget, a scientist who developed theories about the way children's minds work, said that children build concepts from their interactions with peers and adults, and through "hands-on" sensory experiences with objects. For example, children learn a great deal about the properties of rocks by holding, banging, licking, throwing, and washing rocks. Children integrate their sensory experiences into cognitive concepts by learning, with the aid of teachers, the following basic skills of scientific inquiry:

Skill	Definition	Example
Observing	Noticing, gathering information about the world	These rocks are hard.
Identifying	Labeling the information with a name that has a meaning shared with others	This is a rock.
Comparing	Pointing out similarities and differences between objects and events	This rock is gray with black stripes. This rock is all one color.
Classifying	Organizing information into meaningful units based upon comparisons	These rocks have sparkles in them; those rocks don't.
Communicating	Sharing information with others and explaining information to others	This is a quartz rock. It has clear, shiny bumps.
Utilizing	Generalizing information from one experience to another	This rock is sandstone. See how easy it crumbles. I have sandstone rocks at home.

These basic science skills have been identified as developmentally appropriate for young children (Kilmer and Hofman, 1995). Teachers who use developmentally appropriate practice (DAP) regularly encourage children to use these skills. Observing, identifying, comparing, classifying and utilizing information are built in to many activities in a child-centered early childhood program and take place on a daily basis:

Developmentally appropriate classroom practice	Basic science skills
Using a "whole child" approach when planning activities	**Observing** experiences with all five senses (for example, "What do you see?" or "How does it feel?")
Instilling a love of learning through modeling	**Identifying** and **classifying** experiences by using assorted references (for example, books, library, Internet, experts)
Asking questions and making comments that facilitate learning	**Communicating** one's experiences to others (for example, "What happens when you stir the oil into the water?")
Supporting children's curiosity by offering activities that reflect children's interests	**Comparing** experiences with past and current activities (for example, "How is this leaf like the ones you brought to school?")
Encouraging children to solve problems about the physical world	**Utilizing** concepts learned in one situation to solve problems in similar situations (for example, "This weight-scale works like the pan-balance scale you used last week.")

As a result, offering science activities does not require learning a whole new set of teaching strategies. However, it does remind us of what many adults have forgotten—the world is amazing. Children know this; many adults have to relearn it. We need to remember that children absorb nature—experiencing it in its full glory (colors, sights, sounds, smells, textures). Children do not take the natural world for granted. They joyfully revel in it and willingly share their joy with adults.

We can capitalize on children's interest in nature by creating indoor and outdoor physical environments that are rich in natural elements. In this way, we provide many opportunities for children to practice basic science skills.

Harriet E. Huntington (1939), in her classic children's book *Let's Go Outdoors,* reminds us that ordinary creatures—snails, worms, pill bugs, caterpillars—fascinate children. These creatures can be the subjects of hours of observation and conversation.

Rosemary Althouse (1988) builds a science curriculum around natural or manufactured materials familiar to children, including water, color, blocks, boxes, and bubbles. Children explore multiple properties of these easily accessed elements by participating in her science activities.

We also may find that many of our interests—even passions—contain a science element. By sharing our interests with children, we are likely to introduce similar interest in the children. For example, Ms. Hernandez's passion for growing plants native to the area can assist children to plant, nurture and observe a variety of native plants. Ms. Gomez can readily share her love of unusual rocks with children indoors and outdoors. Mr. Goya's wind chime collection can fill the playground with the musical tones of varying-sized wind chimes. His collection inspires the children to build their own chimes that could adorn the entire school. Comparisons of the various tones would sharpen observation, comparison and classifying skills. By offering science activities with concepts familiar to us, we can proceed with confidence and less anxiety.

Natural elements

- bugs
- rocks
- plants
- water
- shade
- sunlight
- classroom pets and cages
- dirt
- natural ground cover
- sand
- sounds in the environment

Planning and setting-up science activities

When planning science activities for young children, we juggle a number of considerations. The more thought we give in advance to an activity, the more likely that the children will realize the concepts underlying their experiences. Here are some guidelines:

Choose new science activities that follow logically from the previous ones. For example, offer colored water and mixing utensils to children who spontaneously mix different colored finger paints.

Follow children's interests when you plan science activities. For example, build on Yeti's interest in a pile of leaves by offering her a collection of leaves of various shapes, sizes, and colors to compare.

Document children's science experiences with photos, written observations, and their own words. This documentation, described in the *project approach,* allows us to track children's interests and building upon previous experiences (Chard, 1994 and Katz and Chard, 1997).

Introduce complex concepts through simple activities. Use a simple pan-balance scale to introduce the concept of comparing weights of the same kind of objects (like teddy bear counters). Later offer more advanced weighing devices that require children to compare an object's weight to a set of standard weights.

Consider whether an activity will be for an individual child or a cooperative event. The choice depends on your goals and objectives, the children's needs, and the nature of the activity. Tracing the path of a marble down and around a plastic route can be an exciting activity for two children to share. It can also be a solitary pursuit for Melanie who needs quiet surroundings and a way to focus her attention.

Consider how much adult coverage the activity requires before offering it to the children. More specifically, ask: Who is available to supervise? What level of supervision (teacher-child ratio) is needed to ensure children's safety? How messy is the activity? Is the activity child-directed or teacher-directed? For example, sifting small rocks from sand is a child-directed activity that requires few directions and relatively little teacher supervision for children who understand that rocks stay out of mouths and the sand stays in the tubs. Baking muffins, however, is usually a teacher-directed activity. It requires attention to child safety, advance material preparation, and the availability of an adult who can talk about mixing ingredients, supervise the baking, and model interest in good nutrition when the children eat the muffins for snack.

Select science materials that are found in the children's home environments, objects the children encounter in their cultural, social, and physical worlds. For example, think about cultural variations in cooking tools and dishes. When you have children identify tools that do or do not hold water, include a tortilla press, a flan dish, and chopsticks. Using only utensils and dishes familiar to the children limits the amount of new information to which they need to pay attention. Familiarity is like the branches of an existing tree on which children grow leaves of new information. It takes less time and effort to grow a leaf than it takes to grow a branch or tree. Familiarity enables children to integrate new information into existing concepts, making learning easier.

> "The most beautiful thing we can experience is the mysterious. It is the source of all true art and science."
> —Albert Einstein

Make sure the science equipment works the way it is intended to work. For example, a pan-balance scale should be adjusted so that the children can clearly see which side holds the heavier load. Ideally, the equipment is open-ended, allowing for variations in how children use it. Younger preschoolers, exploring the properties of the pan-balance scale, may use the pans in a dump-and-fill activity. Older preschoolers who grasp the concept of comparing weights will use the pan-balance scale as a measuring tool.

Use equipment that is aesthetically appealing—that is, pleasing to the senses—and sturdy enough for the children to manipulate without causing damage. Children's actions on the materials should result in clear and immediate feedback so children can make connections between cause and effect. For example, tugging a pulley cord should result in an obvious upward movement of the object suspended from the other end of the cord. Working equipment and immediate feedback have the additional benefits of reducing frustration and increasing the length of time children spend with the activity.

Use equipment that fits children's fine and gross-motor capabilities. For example, young children have difficulty coordinating the movement of a hand-held magnifying glass between their eyes and the object to bring the object into focus. They tend to lay the glass on the object or smash the glass up against their faces. Free-standing magnifiers enable children to successfully view the object because they move their heads and torsos to bring the object into focus.

When you select science equipment and activities, keep in mind that children master gross-motor tasks sooner than fine-motor tasks. Developmentally appropriate equipment frees children to focus on the underlying concepts of the activity.

Set up science activities in a quiet area of the classroom. Shielding children from distractions can help them focus their attention and stick with the activity until it's completed.

How can we promote scientific thinking?

We promote scientific thinking by asking questions. As children answer questions, they learn the basic science skills—observing more carefully, learning names of objects and processes, or comparing things, for example. Most important, questions encourage communication. Children's responses provide a window into what they are thinking and learning, making it possible for you to correct misperceptions or extend their learning.

In preparing questions, consider these guidelines:

- Listen to what the children are saying and watch what they are doing. Thinking about the activity from the children's point of view also helps you anticipate and, therefore, prepare for their questions. Asking open-ended questions encourages children to share their perspective on the activity. Their answers give insight into their thinking. You can use this insight when framing follow-up questions.
- Ask questions that reinforce children's observations and encourage them to continue making observations. For example, 3-year-old Jim asks,

"Why is the sky blue?" Ms. Hinojosa responds, "Why do you think the sky is blue?" She waits for Jim's response, and then says, "Yes, the sky is blue sometimes." She waits for Jim's response, and then says, "Is it blue like your shirt or blue like the blanket?" She waits for Jim's response.

- Ask open-ended questions. Questions that just test children's knowledge ("Is it blue or red?") keep children from sharing their understanding of their experiences. Open-ended questions—what, how, why—stimulate children's thinking. These questions require children to consider many pieces of information before they answer. For example, "Why do you think snails have shells?")
- Be sincere. Ask questions in a genuine, authentic voice, rather than in an artificial or sing-song voice. Indicate honest interest through your tone of voice and facial expression. Sincerity conveys to children that their responses are important. When you allow time for children to think and respond, you show respect for the children and their ideas.
- Focus on things in the here and now. Questions that focus on observable events in the children's immediate environment are more likely to elicit a response than questions about objects or events remote in time or distance from the children. Young children focus on the present rather than the past. They need concrete cues to help them recall the past: "These are the plants you put in soil last week. How are they the same as the plant you brought to school today?"
- Model scientific curiosity by asking questions of yourself and the children. For example, "I wonder what ladybug larvae eat. What do you think they eat?" Ideally, questions enhance the child's experience, not detract from it.
- Balance questions with periods of silence. This provides the child with uninterrupted blocks of time to explore the materials without the distraction of adult questions or comments.

Teachers often express concern that they won't be able to answer a child's question. If this is true for you, try these steps.

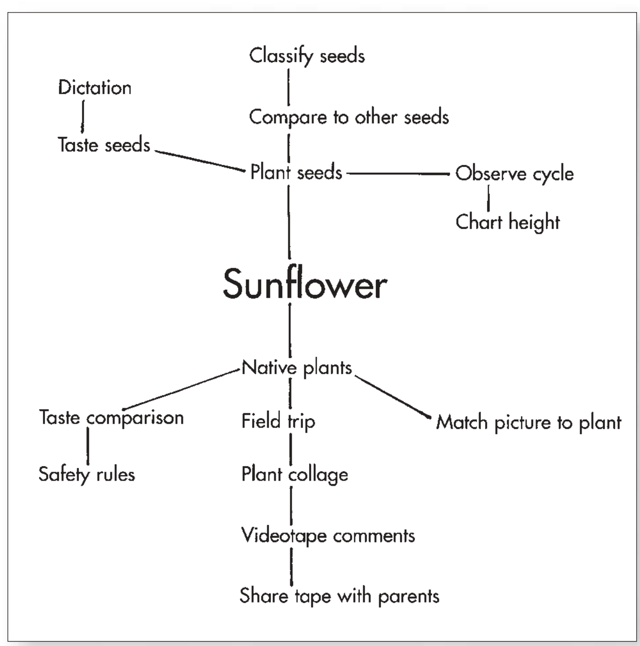
- Anticipate some of the children's questions and research the answers before offering the activity.
- Display basic information of probable interest to the children close to the activity. When the children ask questions, refer to the written display.
- Model how to find answers to questions. For example, a 4-year-old expresses an interest in a bug-eating Venus flytrap. Respond immediately by sharing books or pictures of the plant. Visit the library together to look up information about other plants that eat bugs. Provide a globe so you can both see where the plant originated.

Teachers and children can be co-constructors of knowledge. Helping children understand that learning is a life-long skill that can be refined through practice.

Extending science to other areas of the classroom

The first step in extending science to other areas of the classroom is to identify the concepts associated with the science activity. You can integrate these same concepts into other classroom activities. One way to identify concepts is to use the project approach—in particular topic mapping, (Chard, 1994; Katz and Chard, 1997).

Topic mapping is a form of brainstorming. In topic mapping, you write a central idea or concept in the center of a piece of paper. As you brainstorm, write the ideas that branch out from that topic. Draw a line to connect the brainstormed idea to the central concept or to a subtopic that grows out of the original topic. An example follows:



The central concept in this example of topic mapping is "sunflower." The first subtopic branch is "plant [sunflower] seeds." Several activities flow from the idea of planting seeds:

- observing the seed-to-seed cycle of this plant;
- comparing the appearance of the sunflower seeds to other seeds;
- classifying seeds by size or color;
- communicating thoughts about the taste of sunflower seeds through a dictation posted on the bulletin board; and
- using math skills to draw a bar graph of the changing height of the plant.

The second subtopic that branches from the central concept is "native plants." Ideas flowing from this branch include:

- identifying native plants on a field trip;
- comparing and matching pictures of native plants to actual plants;
- making collages of native plants and communicating ideas about the collages in a videotape;
- comparing the taste of edible native plants to vegetables; and
- using previously discussed safety rules about edible and nonedible items to create rules specific to plants.

The brainstorming could continue indefinitely—or at least until the paper is filled with ideas. Your finished topic map suggests activities for other areas of the classroom—art, math and manipulatives, library, dramatic play, sand and water play, and outdoor activities. In this way, children learn science in every area, throughout the day.

Putting these tips to work

Science at its most basic is discovery. It requires children to use all their senses and learn through a hands-on approach. In offering science activities, teachers use the principles of developmentally appropriate practice.

Teachers who think through science activities in advance are likely to find that they are benefiting from the science experience as much as the children. By helping children practice the basic scientific skills of observing, identifying, comparing, classifying, communicating and utilizing, you refine your own scientific skills. Science becomes real—and enjoyable.

About the authors

Sandi Dillon, Mary Jamsek, P.D. Jolley, Elizabeth L. Morgan, Diana Peyton, and Hallie Speranza are master teachers at the Priscilla Pond Flawn Child and Family Laboratory at the University of Texas at Austin. Carol Armaga is the program director.

Resources for teachers

Althouse, R. *Investigating Science with Young Children.* New York: Teachers College Press, 1988.

Bredekamp, S. and C. Copple. *Developmentally Appropriate Practice in Early Childhood Programs, Revised Edition.* Washington, D.C.: National Association for the Education of Young Children, 1997.

Chard, S.C. *The Project Approach: Book One.* New York: Scholastic, 1994.

Clark, K. "How do caterpillars make cocoons? An adaptation of the Reggio Emilia approach to a kindergarten science project," *Dimensions of Early Childhood* (Spring 1994): 5-9.

Gaylen, N. "Encouraging curiosity at home," *Science and Children* (January 1998): 24-25.

Huntington, H.E. *Let's Go Outdoors.* New York: Doubleday, 1939.

Katz, L. G. and S.C. Chard. *Engaging Children's Minds: The Project Approach.* Norwood, N.J.: Ablex, 1997.

Kilmer, S.J. and H. Hofman. "Transforming science curriculum." *In Reaching Potentials: Transforming Early Childhood Curriculum and Assessment, Volume 2,* S. Bredekamp and T. Rosegrant, eds. Washington, D.C.: National Association for the Education of Young Children, 1995.

Rivken, M. "Science is a way of life," *Young Children* (May 1992): 4-16.

Ross, M.E. "Scientists at play," *Science and Children* (May 1997): 35-38.