Building engaging science labs—outdoors

by Heather Olsen, Susan Hudson, and Donna Thompson

"**OK,** time's up," says Ms. Bridget, clapping her hands. "Let's see what you've found."

She guides the 4-year-olds into a circle on a blanket of newspapers covering the cold ground. The children begin to empty their paper bags to reveal nuts, twigs, rocks, leaves, seeds, and a feather.

"What are these, and where did you find them?" Ms. Bridget asks Mindy. The child points to the large oak tree by the back fence.

"Acorns!" cries Daniel. "We have those at our house."

"What would happen if you pushed this acorn into the ground and covered it with dirt?" Ms. Bridget asks the group.

"It would be lost," says one child, slowly shaking his head.

"A bird might find it," says another child, imitating a bird pecking around on the ground.

"No," Daniel insists. "It would grow into a tree."

Mindy takes a closer look at an acorn, her eyes growing wide. "Is there a little bitty tree in there?"

■ ■ ■

Many early childhood teachers, like Ms. Bridget, take advantage of the outdoors as an extension of the classroom. Except in the worst weather, the outdoors offers a place for many kinds of learning activities, such as reading and telling stories, painting and modeling with clay, marching in a rhythm band, and—especially—learning science.

The best designed outdoor classrooms are those that invite children to explore, follow curiosity, and engage in rich sensory experiences. Research shows that young children's thinking is sophisticated. They are capable of a wide range of reasoning processes used in science: observe, describe, compare, question, predict, experiment, and reflect (Barnett et al. 2007; National Science Teachers Association 2009; Yoon and Onchwari 2006). In addition, as experienced teachers know, young children have a sense of wonder about the world.

Bringing children outdoors for science is timely, given the movement in recent years to reconnect children to the natural world (Charles et al. 2008). (To learn more about this movement, see the report *Children and Nature 2008* at www.childrenandnature.org/downloads/CNMovement.pdf.)

Scholars argue that children develop psychologically and cognitively as well as live happier and healthier lives when they are given opportunities to play in the outdoors (Clements 2004; Kellert 2002). It makes sense, then, to turn outdoor spaces into exploratory places where children are free to investigate, manipulate, and observe.

The outdoor environment is filled with informal learning possibilities. But for these possibilities to

CHILDREN DEVELOP PSYCHOLOGICALLY AND COGNITIVELY AS WELL AS LIVE HAPPIER AND HEALTHIER LIVES WHEN THEY ARE

GIVEN OPPORTUNITIES TO PLAY IN THE OUTDOORS.

materialize, outdoor environments need to be designed and planned. It is through planning that young children can be provided with the time and opportunity to become young scientists. This article offers tips on designing quality and safe outdoor environments to enhance science inquiry.

Can children learn science outside?

Before planning for informal science concepts in the outdoors, teachers need to reflect on whether children can engage in science concepts outside. The first step is to ask if you truly believe that children's play experiences can foster a sense of discovery in the outdoors. Learning and discovering through play is based on theories of John Dewey and Jean Piaget, who believed that young children learn best through their play experiences.

The National Association for the Education of Young Children states: "Young children are scientists at play" (2002). It is through play that children can develop an understanding about life and its meanings.

Science is everywhere outside. With proper planning, the design of the outdoor environment allows children to construct a meaningful understanding of the world. Playful discovery happens when teachers plan environments that stimulate children's thinking and are interesting and familiar (Martin et al. 1998).

Teachers create magical moments for children by exposing them to places that encourage imagination, exploration, discovery, and manipulation. Teachers need to maximize outdoor spaces so children have the opportunity for scientific discovery.

Creating quality outdoor science environments involves four components:

1. The environment must be SAFE™ (Thompson et al. 2008).
2. Children are given plenty of time to explore.
3. The space has plenty of manipulative objects for children to investigate.
4. The space is purposeful.

1. Creating a SAFE™ environment. Children grow physically, socially, emotionally, and intellectually when the outdoor environment is SAFE™. The National Program for Playground Safety identifies four factors of injury risk for children on playgrounds: Supervision, Age-appropriate design of equipment, Fall surfacing, and Equipment and surfacing maintenance (Thompson et al. 2007).

S Supervision is crucial to prevent injuries and avoid potential lawsuits. A supervisor's role is to select the best materials for the environment so that lessons can be effective.

A Age-appropriate design refers to a play environment that meets the developmental skills and abilities of the children using it.

F Fall surfacing under and around slides, swings, climbers, and other playground equipment must be resilient to prevent injury if a child falls while playing. (State regulations may specify surfacing coverage and depth.)

E Equipment maintenance of the play areas includes eliminating hazards and keeping the materials in the outdoor environment in good condition.

2. Children are given plenty of time to explore. Children learn how to learn by having enough time to explore, perform experiments, and solve problems. Exploring, investigating, and problem solving takes time. Children need time to become engaged, work through puzzling situations, and reflect on their findings. Sometimes children need time for their sense of wonder to come alive.

3. The space has plenty of manipulative objects for children to investigate. Children love to engage with the physical environment and the pieces in these spaces (Nicholson 1971; Moore 1986). Manipulative objects are materials that children can pick up, sort, arrange, and collect.

Examples include the following:

- holding containers,
- sand toys,
- building toys (such as blocks and boxes),
- wheeled toys,
- natural materials (such as pine cones, rocks, mud, sticks, and smooth stones),
- art supplies (such as brushes, paint, cups, water tables, sponges), and
- dramatic play toys (such as kitchen materials and cooking utensils, dress-up clothes, dolls, and action figures).

"Loose parts," such as those above, make the outdoor play environment complete (Dempsey and Strickland 1999). It's important to provide a variety of materials and enough of them so each child has the opportunity to manipulate and explore.

4. The space is purposeful. Typically, the outdoor environment has been viewed as "the playground" comprised of play structures, and its purpose has been seen as a kind of school recess. As such, children are let loose to enjoy "free time" in the environment, while staff members congregate and take a rest from interaction in the indoor classroom.

But the benefits of the outdoor play environment are more extensive than "burning energy" and taking a break from academics. Educational research is rich with empirical evidence supporting the relationship between play and learning. In particular, children are able to socialize with their peers and explore the environment using their five senses.

Making a space that is purposeful does not necessarily mean a formal structure as found in the indoor classroom. Instead, the staff sees the outdoor environment as an extension of the indoor classroom and arranges the outdoor environment to supplement the indoor curriculum. For instance, if story time is about Peter Rabbit, then outdoor time might be spent in a garden area harvesting vegetables that Peter and his friends might eat.

Different types of science

Science must be relevant to children. It must be taught in a way that allows them to construct meaningful understanding from their experiences. Teachers need to interlace science concepts into everyday play opportunities. This can be achieved through offering the fundamental concepts of life science, physical science, and earth science into the outdoors. See the checklist on page 36 for suggested manipulative materials for each type of science.

Life science

Life science allows children to develop an understanding of the differences between living and nonliving things. Life science gives children a chance to closely observe, care for, and enjoy living things.

The three major components of life science are biology, physiology, and ecology. *Biology* is the study of life, such as plants and animals. *Physiology* refers to the functions and behaviors of living things. *Ecology* is the relationship between living things and their environment.

There are many options for teaching life sciences, but the simplest technique is to have children explore their immediate outdoor classroom. A preschool in Florida might grow and study an orange tree, while children in Nebraska may want to plant and care for corn or beans. Young children need experiences that they can directly relate to their surroundings.

The outdoor environment has life science when it incorporates living things such as plants and animals and how they interact with their environment. Young children are involved in life science when they are working with manipulative objects that include seeds, plants, birdhouses, bird feeders, bug nets, magnifying glasses, bug holding containers, magnifying glasses, worms, binoculars, clear containers, and stethoscopes.

THE BEST DESIGNED OUTDOOR CLASSROOMS ARE THOSE THAT
INVITE CHILDREN TO EXPLORE, FOLLOW CURIOSITY,

AND ENGAGE IN RICH SENSORY EXPERIENCES.

For instance, consider what could happen if children were given seeds to plant. Planting seeds outside is a wonderful opportunity to discuss what is needed for living things to grow and develop. Children can discover how to care for the seeds through providing the right amount of water, nutritious soil, and sunlight. Other days, bug nets and holding containers could be available to allow children to discover how living creatures share the outdoor space.

Physical science

Physical science is the study of nonliving things. It involves the investigation of physical properties, such as the principles of physics and chemistry. Physics and chemistry may sound scary to some educators, but the fundamentals are accessible to everyone.

Indoor classrooms do a good job of providing physical science by encouraging children to investigate size, color, weight, and shapes of objects. Other basic physical science learning occurs in activities with water (float, sink, flow, freeze) and air (temperature, blowing).

Unfortunately, many outdoor spaces are not designed to allow children to connect with physical sciences. But teachers can use common outdoor play equipment in creative ways. For example, teachers can help spark curiosity by allowing children to explore motion through wheeled toys. Why is pulling a wagon easier on concrete than on grass? What's different about rolling a toy truck on a path, up a ramp, and through a tunnel?

Teachers can also engage children in experiments with balls, blocks, and building materials as well as materials such as sand, dirt, and water. Teachers can create physical science activities well-suited to the outdoors such as flying paper airplanes and kites.

Many indoor activities can be brought outdoors. Science tools such as magnets, magnifying glasses, levers, balances and weights, bicycle tire pumps, and prisms are obvious choices. Kitchen utensils such as spoons, strainers, funnels, and eggbeaters add interest to sand and water activities. Simple—and messy—experiments such as mixing baking soda with vinegar and blowing bubbles with different utensils are easily done outdoors.

Children can become involved with these objects individually or in groups. Physical science inquiry starts with explorations that lead children to learn differences and similarities and question cause-and-effect relationships.

Earth science

Earth science is the study of the earth and its size, shape, and makeup. It's about studying the earth's behavior, the environment, and natural components. Earth science curriculum includes studying the properties of the earth, ocean, atmosphere, weather, geology, astronomy, and the universe.

Many young children are not regularly exposed to the natural world. Research shows an enormous increase in the use of electronics, television, technology, and video games in young children's lives. Richard Louv (2008) in his book *Last Child in the Woods* argues that children are so plugged into television and video games that nature has come to be perceived as a kind of a "bogeyman."

Teachers and teacher educators play a major role in continually seeking activities that keep children aware of the world around them. Creating outdoor spaces that allow children to explore and to learn about the world's natural elements enhances their understanding and appreciation of the environment.

Young children are doing earth science when they explore the clouds, sun, shadows, moon, rocks, water, snow, rain, grass, dirt, trees, and shrubs. Young children love to collect objects. Teachers need to provide enough holding containers for children's collections.

Manipulative objects that enhance earth science include telescope, rain gauges, thermometer, maps, pictures, and sand and water tables. Teachers may want to consider providing craft materials in the outdoor space so children can document what they see and hear. Then children can record their observations. For example, children can use a logbook to draw, paint, or color what they observe outside. They can use digital cameras to record changes in plant growth, leaf color, and weather.

Providing developmentally appropriate outdoor science concepts

Young children need to play with manipulative materials that fit their developmental abilities. Many manipulative materials, especially natural materials (such as stones, pine cones, seeds, and feathers) are free or inexpensive.

When looking at the outdoors as an extension of the classroom, teachers need to remember that all outdoor spaces and children are different. Before rushing to the catalog to buy items or placing every

manipulative material in the outdoor environment, teachers need to have a plan in place. The first step is to decide the types of science experiences children should have in the outdoors. The curriculum will influence the planning process.

The second step is to determine who will be using the outdoor space. The type of learning experience will vary depending on the children's developmental abilities. Earth science for a 2-year-old is different from that for a 4-year-old. Two-year-olds may be excited about collecting and sorting rocks, whereas 4-year-olds might want to experiment with the rocks' weight, size, color, and shape.

The third step is to consider the outdoor resources. These resources include environmental elements, hazardous conditions, and storage units that may be present. For instance, the topography or drainage can be problematic. On one hand, mud puddles and other naturally occurring water can be a great learning tool for the children. But the water should not be draining from a sewer or other toxic location. Nor should the water be left standing long enough to breed mosquitoes.

Another environmental element is shade to protect children from UV rays and sunburn. Shade may be available from trees or from structures such as patio covers or sheets draped over chairs.

Hazardous elements include utility lines, roads, parking lots, water ponds, and air-conditioning units. These elements are constraints and need to be fenced off. Air-conditioning units and utility boxes should be completely enclosed so no children have access.

Storage units outside are a necessity but are often overlooked (Grounds for Play 2009). Because teachers are strapped for time, materials used outdoors need to be stored at a location convenient to teachers and children. Having more than one storage unit in areas where children play is ideal. Sturdy construction, secure locks, and shelving are important features.

Design high quality outdoor science labs

Outdoor spaces are filled with possibilities for science experiences. To ensure high quality experiences, teachers need to design SAFE™ spaces, give children

Manipulative materials for outdoor science: A checklist

	Does the outdoor space include:		
Life Science	▪ Planting materials (seeds, gardens greenhouses)	☐ Yes	☐ No
	▪ Bug nets	☐ Yes	☐ No
	▪ Magnifying glasses	☐ Yes	☐ No
	▪ Clear containers	☐ Yes	☐ No
	▪ Birdhouses/Bird feeders	☐ Yes	☐ No
Physical Science	▪ Magnets	☐ Yes	☐ No
	▪ Balances and weights	☐ Yes	☐ No
	▪ Water/Sand	☐ Yes	☐ No
	▪ Balls, wheeled toys	☐ Yes	☐ No
	▪ Ramps, pathways, levers	☐ Yes	☐ No
Earth Science	▪ Variety of natural elements (rocks, tree stumps, boulders)	☐ Yes	☐ No
	▪ Thermometers	☐ Yes	☐ No
	▪ Rain gauges	☐ Yes	☐ No
	▪ Representations of the earth (maps, pictures, globe)	☐ Yes	☐ No
	▪ Dirt digging area	☐ Yes	☐ No

Evaluation: If you are able to answer yes to:
- 15 - 13 of these questions, your outdoor environment is filled with science opportunities.
- 12 - 9 of these questions, the children may be engaged in the environment, but it will require your extra effort and preparation.
- 8 or fewer of these questions, you may want to spend time planning for science curriculum outdoors.

plenty of time to explore, provide plenty of manipulative objects, and plan purposeful activities.

Teachers can make science relevant to children's everyday play experiences by incorporating basic principles of life science, physical science, and earth science. When equipped with age-appropriate tools and materials, the outside environment becomes an exciting place for children to observe, collect, describe, predict, experiment, and reflect.

References

Barnett, D.W.; A.M. VanDerHeyden; and J.C. Witt. 2007. Achieving science-based practices through response to intervention: What it might look like in preschools. *Journal of Educational & Psychological Consultation* 17 (1): 31-54.

Charles, C.; Richard Louv; Lee Bodner; and Bill Guns. 2008. *Children and Nature 2008: A Report on the Movement to Reconnect Children to the Natural World.* Sante Fe, N.M: Children and Nature Network.

Clements, R. 2004. An investigation of the state of outdoor play. *Contemporary Issues in Early Childhood* 5 (1): 68-80.

Dempsey, J., and E. Strickland. 1999. Staff workshop teacher handout: The whys have it! Why to include loose parts on the playground. *Early Childhood Today* 14 (1): 24-25.

Grounds for Play. 2009. Storage and shade structures. www.groundsforplay.com/storage.html.

Kellert, S. 2002. Experiencing nature: Affective, cognitive, and evaluative development in children. In *Children and Nature,* P. Kahn and S. Kellert, eds. Cambridge, Mass.: MIT Press.

Louv, R. 2008. *Last Child in the Woods: Saving Our Children From Nature-Deficit Disorder.* Chapel Hill, N.C.: Algonquin Books.

Martin, R.; C. Sexton; K. Wagner; and J. Gerlovich. 1998. *Science for All Children: Methods for Constructing Understanding.* Needham Heights, Mass.: Allyn and Bacon.

Moore, R., and H. Wong. 1997. *Natural Learning: Creating Environments for Rediscovering Nature's Way of Teaching.* Berkeley: MIG Communications.

National Association for the Education of Young Children. 2002. "Starting Children on Science," in *Early Years Are Learning Years*™ series. NAEYC. www.naeyc.org/families/early_years.

National Science Teachers Association. 2009. Executive Summary: *Taking Science to School: Learning and Teaching Science in K-8,* http://science.nsta.org/nstaexpress/nstaexpress_2006_09_25_execsummary.htm.

Nicholson, S. 1971. How not to cheat children: The theory of loose parts. *Landscape Architecture* 62 (1): 30-35.

Thompson, D.; S. Hudson; and H. Olsen 2007. *S.A.F.E. Play Areas: Creation, Maintenance, and Renovation.* Champaign, Ill.: Human Kinetics.

Yoon, J.; and J.A. Onchwari. 2006. Teaching young children science: Three key points. *Early Childhood Education Journal* 33: 419-423.

About the authors

Heather Olsen, D.Ed., an assistant professor at the University of Northern Iowa and assistant director of the National Program for Playground Safety, has been associated with the development of outdoor play areas for children and educating the public about age appropriateness, supervision, and maintenance. She has given presentations throughout the country about the design of safe play areas and has written articles on creating quality play areas.

Susan Hudson, Ph.D., holds one of three endowed professorships in the United States in leisure and youth services. She has a distinguished record of teaching, research, and service, including serving as division coordinator and coordinator of graduate studies at the University of Northern Iowa. She is also the education director of the National Program for Playground Safety.

Donna Thompson, Ph.D., is a national and international expert in playground development and safety and the executive director of the National Program for Playground Safety. She has more than 20 years experience teaching, writing, and researching about playgrounds. She has done numerous presentations on playground development, including network television interviews, and served as consultant for numerous groups planning playgrounds.