The early years and the types of science experiences young children have are instrumental in fostering positive attitudes toward science, beliefs in its usefulness to their own lives, and positive self-identities as capable science doers, thinkers, and learners (Pattison & Ramos Montañez 2022). Positive and engaging early experiences with science can ignite children's passions for specific topics of study that last into adulthood (Funk & Hefferon 2016).

Teaching and Learning in Science

All science teaching in the early childhood curriculum should build on children's innate curiosity and desire to explore their surroundings (Jirout 2022). Children need many opportunities to explore independently and with peers and to experience guided inquiry with the teacher's facilitation. They rely on adults to provide a "fascination-rich" environment, to support their explorations in a variety of ways, and to facilitate their reflection and sense making.

Multiple Pathways to Science Inquiry and Learning

The vignettes earlier in the chapter illustrate how children naturally engage with the science and engineering practices when questions, problems, or discoveries arise during play. Teachers can support this inquiry by helping children articulate their questions; try new ways to investigate phenomena; observe, collect, and record data; share and reflect on experiences; and generate ideas based on evidence from their observations.

You can support science inquiry and learning in various ways:

- Through single, stand-alone activities, such as sinking and floating, tracing shadows outdoors, or pumpkin carving. These adult-guided experiences aim to teach discrete information (such as that items sink or float in water, people's shadows change from morning to afternoon, and a pumpkin contains many seeds). A drawback of such activities is that they often focus on facts rather than big ideas, sometimes even promoting children's misconceptions (such as that items sink or float based on their weight or that only the sun creates shadows). Inquiry is limited to making and evaluating predictions as right or wrong. You can increase the inquiry potential of these activities by identifying a big idea for further exploration (for example, a shadow is created when an object blocks the path of the light); introducing an exploration message (for example, "We can explore our own shadows indoors and outdoors"); and extending the experience to include collecting, representing, and analyzing data (for example, "How is your shadow similar to and different from you?") and making claims based on evidence (for example, "My shadow is the same shape as me, but it has no eyes, no nose, and no mouth").

- Through informational texts or storybooks focused on science concepts, such as *Who Sank the Boat?* by Pamela Allen; *Me and My Shadow* by Arthur Dorros, or *From Seed to Pumpkin* by Wendy Pfeffer. Preferably, these are extensions of children's own explorations. Books in science can best serve as references or resources to prompt new exploration ideas, observe authentic images of phenomena, illustrate new perspectives, and reinforce vocabulary.
- In response to a question, problem, or unexpected event that arises during play. This could lead to independent inquiry, or teachers can leverage these moments to guide children's exploration. The sidebar "A Problem Launches Inquiry: Why Aren't the Clothes All Dry?" more fully describes this pathway.
- By implementing a "topics of study" approach that promotes cycles of inquiry around related big ideas in physical, life, or earth and space science. Well-chosen topics are anchored in a big idea, maximize hands-on and minds-on inquiry, and can be explored and discussed over time and across settings.

The Role of Children's Preconceptions in Science

Children's beginning explanations about how and why things happen are generally not scientifically correct (for example, hard hats make towers stronger; worms like bedtime stories; plants are not living; the sun goes around the earth; all round things float; heavy balls roll faster than light ones). This is to be expected because children have a limited range of experiences to draw on. However, such preconceptions are important milestones in children's efforts to make sense of the world and how it works, because they represent opportunities for reflection and provide launching pads for further inquiry.

Early childhood educators don't have to be science experts to be excellent science teachers. Teaching science in preschool does require a willingness to build your own knowledge and skills, so consider accessing science resources to do that. Engage in your own science inquiry on a topic before introducing it to children. Resist the urge to provide oversimplified scientific explanations, and don't hesitate to say, "I don't know. I wonder how we can figure that out together."

Science Topics That Excite and Engage Young Children

The domains of physical, life, and earth and space science each present opportunities for exploring a wide range of everyday phenomena that children find fascinating and that many adults take for granted. For example, water draws the attention of young children and can be explored from different perspectives: as a liquid and how it moves and flows (physical science), as a survival need for all living things (life science), or as a material in Earth's ponds, lakes, and oceans (earth and space science).

A Problem Launches Inquiry: Why Aren't the Clothes All Dry?

As you read the following vignette, look for how an exploration emerges from children's play, how they engage with the science and engineering practices, and how their interactions with the teacher support their thinking and ongoing investigation.

1. **A problem arises during the children's play that is unexpected.**

   The children in Mrs. Takanishi's preschool class wash all the doll clothes in the morning and hang them outside to dry. When they go outside in the afternoon to bring the doll clothes in, they discover that some are dry, some are still damp, and several are nearly as wet as they were when the children hung them up in the morning!

   "Now I can't put the blue shirt on Sam [a doll]," says Manuel, disappointed.

   "You can use the red one," says Ivan to Manuel. "It's dry."

   Manuel accepts the red shirt from Ivan but eyes the blue shirt longingly.

2. **The children identify a relationship between the sun and the dry clothes.**

   Mrs. Takanishi knows that her preschoolers won't reach a scientific explanation, but she sees a good opportunity to support their inquiry in relation to properties of matter (the colors and structures of the different fabrics) and energy (the sun warms the earth's surface). She asks, "Do you have any ideas about why some doll clothes are dry, some are a little wet, and some are still very wet?"

   The children share their thinking with comments such as "Maybe because the blue shirt is bigger and it takes longer to dry," "The yellow dress is even bigger than the blue shirt, and it's dry already," and "Maybe yellow clothes dry faster than blue clothes?"

   "Mmm," says Mrs. Takanishi. "The yellow dress and the red shirt are both dry, and they are next to each other on the clothesline. I wonder if that matters."

   Ivan says, "Hey, I can see the shadows of the red shirt and the yellow dress on the ground!"

   "I know!" exclaims Soledad. I can only see my shadow really good on sunny days! The sun made the clothes dry!" There is a chorus of agreement.

3. **The children explore further and collect data that does not "fit" with their first explanation.**

   Mrs. Takanishi acknowledges the children's thinking and raises a question. "So you're thinking some clothes are dry because they're in the sun and some clothes are wet because they're in the shade. Okay. Does that mean you're predicting that all the clothes in the sun will be dry?"

   "Yes!" says Manuel. "We'll show you! Me and Jenna can feel the ones in the sun. Ivan and Soledad, you feel the ones in the shade!"

   The children divide into two groups and call out their observations. They soon make another discovery. A couple of items in the sun are still wet and a couple in the shade are dry.

   "So, some clothes in the sun are still a little wet, and some clothes in the shade are dry," says Mrs. Takanishi to confirm their observations.

4. **The children generate ideas to explain new evidence and make a plan to continue their exploration the next day.**

   "Did you move them?" Ivan asks Mrs. Takanishi.

   "No," she answers, laughing. "I was inside the classroom with you all morning. What other ideas do you have?"

   The children offer explanations, including "White clothes dry faster than purple clothes" and "At the beach my bathing suit dried quick, but my towel took longer because it's like a blanket." Charlotte remembers an activity the class did with sponges and water and suggests that maybe they hadn't "squeezed all the water out of the wet clothes."

   Back in the classroom, Mrs. Takanishi lists all the ideas on chart paper and helps the children make a plan to investigate further.

   They decide that the next day they will wash two identical shirts and hang one in the sun and one in the shade. Mrs. Takanishi suggests that tomorrow they also look at the clothes in the sun that took longer to dry and see if they are similar in any ways.

   Manuel takes the dry red shirt inside. "I sure hope it fits Sam," he says.

Adding materials that extend children's exploration of how water looks, moves, and flows supports their learning about water as a liquid.

Children's Inquiry and Learning in Physical Science

Physical science inquiry is especially rich with opportunities for direct, hands-on exploration, and children can immediately observe the effects of their actions on objects and materials. Early childhood programs, with block areas, water and sand tables, manipulative toys, musical instruments, art areas, and outdoor areas, are well-suited for physical science explorations at any time of year. Children engage with physical science as they, for example, design and build block structures; discover different shades of red when mixing colors at the easel; create a system to move water in the water table using basters and clear tubing; and notice vibrations as they create and use instruments to make sound. Children may ask or wonder about questions such as "Which blocks will make the tallest tower?," "How can I make an even darker red?," "How hard do I have to push this ball to get it up the ramp without falling off at the top?," "Which of these tools will squirt water the farthest?," or "How does changing the container change the sound the pebbles make?"

Children's Inquiry and Learning in Life Science

Life science inquiry is primarily observational, and from a preschooler's perspective, plants and animals take a long time to grow and change. Life science explorations also involve ethical considerations that don't apply in physical science. Inquiry outdoors is influenced by geographical location, climate, and weather.

As members of the living world, young children are fascinated by their own growth and development and by the characteristics and behaviors of other living things, especially animals. Children engage with life science concepts as they, for example, investigate and categorize seeds, measure their own growth over time, observe a tree in the playground over the course of the year, create temporary indoor habitats for insects and other small creatures, nurture plants in a school garden to maturity, and compare how they are similar to and different from other family members. Children's wonderings about the living world may include "How do plants eat?," "How can trees be alive?," "How do seeds know what plant to grow into?," "Are worms baby snakes?," "Do bugs have teeth?," "Why do dogs chase cats?," and "Where did the dinosaurs go?"

Children's Inquiry and Learning in Earth and Space Science

Earth and space science incorporate elements of both physical and life science and are especially enjoyable to young children, who love being outdoors and exploring nature in all weather conditions. Children engage with earth and space concepts when, for example, they play with and investigate their shadows; compare different types of soil, sand, and rocks; collect data about the weather using rain gauges and windsocks; engage in reduce, reuse, and recycle activities; and explore and enrich outdoor habitats that provide homes for plants and animals. Extended weather charting routines across the year engage children in observing the sun, clouds, wind, temperature, and precipitation, as well as using and creating measurement tools that deepen their inquiry and learning about weather. Children's questions and wonderings related to earth and space science may include "Why do puddles form in some places but not others?," "Why doesn't it ever snow where we live?," "Where does my shadow go when it's cloudy?," and even "Are the shaking trees making the wind blow?"

Drawing the ramps they built supports children's abilities to create scientific representations and their literacy and fine motor skills.

Integrating Science with Other Learning

Science is a perfect vehicle for integrated teaching and learning. Doing science supports underlying cognitive skills, such as executive function (the "air traffic control center" of the brain; see Chapter 3), that are critical to developing more easily observed academic school-readiness skills—for example, knowledge of letters and print (Center on the Developing Child, n.d.). Science promotes language and literacy development and learning as children share their observations, ideas, and explanations with others through talking, drawing, and writing (Duke 2019). As they engage in inquiry, children use mathematics and computational thinking as they count, measure, organize, and analyze their data and as they use vocabulary to describe size, shape, length, and weight. Representing their science-related actions and ideas through painting, creating models, and dramatic play engages children in the arts. Science also supports the broad skill sets so important in an increasingly science- and technology-oriented world and workforce: critical thinking (evidence-based thinking) and problem solving, collaboration, communication, and creativity and innovation (Center for Childhood Creativity 2017).

Materials That Promote Inquiry and Exploration

Provide materials that promote scientific inquiry throughout the classroom and the outdoor play space, beyond a designated science area or center. Consider these suggestions:

Art center: Paint pumps, craft sticks, plastic spoons, brushes, ink pad and stamps, stapler, hole punch, scissors, plastic molds, tape, glue, string, yarn, ribbon, large-eyed tapestry needles, buttons, beads, pipe cleaners, rolling pin, wire or canvas mesh, fabric scraps, straws, paper clips

Dramatic play center: Cooking utensils (wooden spoon, spatula, ladle, whisk, tongs, funnel, scoop, garlic press, measuring cups and spoons, timer, potholders, bag clips, food mill, rolling pin, cookie cutter, colander), cleaning equipment (broom, dustpan, vacuum cleaner, buckets, sponges, rubber gloves, clothespins), medical equipment (stethoscope, blood pressure cuff, slings, canes, crutches, syringes, gauze pads, adhesive tape), dress-up clothes with various types of fasteners (zippers, buttons, hook-and-loop tape, snaps), keys, telephone, toaster, stove, mailbox

Block center: Wood blocks, cardboard blocks, foam units, wood chips and shims, ruler, yardstick, measuring tape, cartons and boxes, large elastic bands, foam padding, tape

Woodworking center: Screwdrivers, hammers, pliers, clamps, hand drills, levels, dowels, fasteners, and other hardware (nails, screws, nuts, bolts, washers)

Sand table: Pails and shovels, plastic containers of different shapes and sizes, muffin tins, mesh strainers

Water table: Turkey basters, dish soap, bubble wands, funnels, clear plastic tubing and connectors, squirt and spray bottles, pipettes

Outdoor play space: Sand and water table equipment, rope, wagon, sawhorses, dump truck, wheelbarrow, gardening tools (spade, hoe, rake, gardening gloves, kneeling pads, watering can, hose), balls, hand pump (to inflate balls), construction materials (wood scraps of different sizes and shapes), containers for collecting things

Connecting Teaching to Children's Lives

By Melany Spiehs

During morning center time Skylar, age 4, and Luna, age 5, play in the classroom loft. Skylar dangles a long piece of yarn over the side, and Miguel, age 3, reaches up from below to get it. Curious, Ms. Ellison moves closer to the action, watching and listening.

Luna: You can't play up here, Miguel. We already have three friends in the loft.

Miguel: I know that. I just want to give you something I made in art center.

Skylar: Tie it to our string, and we can pull it up.

Miguel struggles with the yarn for a few minutes trying to attach his craft stick creation. Eventually he decides to wrap the yarn around his art piece, and the girls start to pull it up using the top rail of the loft as leverage. The artwork makes it halfway up but breaks free of the yarn before the girls can grab it.

Ms. Ellison realizes the students are engineering a pulley system and asks guiding questions.

Ms. Ellison: What is it you are working on here? I wonder how we could get Miguel's artwork up to you without it falling back down? Is there something we could attach to the yarn?

Skylar: I think we need a bucket. My dad uses a bucket to carry nails up to the roof at work.

Luna: We could get a bucket from the sand table!

Ms. Ellison: Who wants to try tying the knot?

Luna: I do! (*Ties the string to the bucket with some help from Ms. Ellison.*)

Miguel: (*Puts his art in the bucket and smiles as his friends pull the bucket to the top of the loft.*)

Luna: Cool, Miguel! I like your art.

Miguel: It's for you.

Luna: Thank you. Will you put it in my cubby? I'm going to lower it back down in the bucket.

The other children observe and ask to try the simple machine. Over the next several weeks the class explores pulley systems. Ms. Ellison refreshes her knowledge of simple machines, and the class learns about the parts of a pulley, how pulleys work, and how people use them in everyday life to open window blinds or ride in an elevator. The class creates small pulley systems in the block center and large pulley systems in their outdoor classroom over tree branches. The children are amazed at how much weight they can lift using a pulley system!

In this vignette, the children exhibit collaborative problem-solving skills as they engineer a simple machine to solve a problem that arises during their play. Using her funds of knowledge, Skylar references a time she saw her father using a bucket in his work. The cooperative nature of this experience honors a community value of working together to accomplish a goal. Ms. Ellison provides support by asking questions that help children reflect on and revise their original plans. The children explore engineering naturally, and Ms. Ellison provides vocabulary, materials, and experiences that extend the physical science and engineering embedded in their play. Ms. Ellison integrates mathematics into this experience by discussing measurement concepts like weight and height. Ms. Ellison's inquisitive approach and attentiveness to the children's ideas facilitate both their critical thinking and problem solving.

Fitting the Learning Experience to the Learning Objective

Engaging young children in the three domains of science—physical, life, and earth and space—is essential for their holistic development and for building an understanding of the world around them. Explorations in all the domains support children's inquiry, their positive science identities, and their scientific habits of mind. Teachers maximize children's inquiry and thinking through both child-guided and adult-guided experiences.

Exploring Physical Science

Of the key knowledge and skills in the area of physical science, child-guided experiences seem particularly important for the following:

- Exploring objects and materials
- Identifying and solving problems that arise in play

Adult-guided experiences seem to be especially significant for the following:

- Expressing investigation questions using language
- Making reasoned predictions
- Generating claims, explanations, and solutions

CHILD-GUIDED experiences are especially important for learnings such as:

Exploring Physical Science › **Exploring objects and materials**

Children need uninterrupted time to gain familiarity with new objects and materials and how they can be used, so they benefit from multiple chances to play, build, and create with a variety of items. These child-guided experiences create equity among children who have had varying levels of experience with the materials and pave the way for more focused investigations as children begin to raise questions about what, how, and why different objects and materials behave as they do.

Teaching strategies. Help children extend their investigations with strategies like these:

- Add new objects and materials to the learning areas or rotate objects across areas that prompt children to explore in new ways. For example, add tree blocks (blocks made of actual branches) or plastic cups to the building center that don't stack as easily as unit blocks; colored transparent building tiles to a shadow center for observing colored shadows; basters, clear tubing, and funnels to the water table to explore water flow; or sponges instead of paintbrushes at the easel to expand children's experience with tools.
- Be responsive to children's ideas and suggestions for using classroom materials. For example, encourage them to try out their idea for using tape to secure their block structures or paint to embellish their playdough creations.
- Adapt science materials and experiences as needed to support children with developmental delays or disabilities. For example, provide one or two new items at a time so they can become familiar before being introduced to more. Periodically partner children with developmental delays or disabilities with peers to explore materials together, especially if a child does not have one-on-one adult support.

Exploring force and motion motivates children to design and build structures that will make objects move using a variety of materials.

Exploring Physical Science › **Identifying and solving problems that arise in play**

Young children's inquiry is stimulated when problems or discrepant events (that is, things they didn't expect) arise, such as a ball repeatedly skipping off a ramp or a different color appearing than what they anticipated in a color-mixing activity.

Teaching strategies. Use strategies such as these to support children's problem solving:

- Avoid the temptation to jump in and explain or solve children's problems for them. Instead, ask questions that help them observe more closely (for example, "Where exactly is the ball jumping off the ramp? What do you notice about where those two boards come together?") or make suggestions (for example, "What have you tried already?" or "Have you tried putting the boards closer together?").
- Remind children of a prior experience in which they had a similar problem and how they solved it (for example, "Remember last time when you got light pink, but you wanted dark pink? What did you do to make the pink darker that time?").
- Encourage children to ask each other for help. Try making a list with suggestions for peers children can go to when different problems arise (such as "When you can't reach something up high, go to Johanna" or "When you need help mixing paints, ask Michael"). Ensure every child in the classroom is included as an "expert."

ADULT-GUIDED experiences are especially important for learnings such as:

Exploring Physical Science › **Expressing investigation questions using language**

Although young children wonder about everything, they often need support to articulate their questions. Because cognition and language go hand in hand, supporting children to verbalize their questions also supports their thinking.

Teaching strategies. Try the following strategies to help children articulate their questions:

- Play alongside children and model asking questions out loud. For example, you might build alongside them in the block area and say, "I wonder how I could make a doorway in my barn." Model collaboration by asking to join children's play or inviting them to join yours.
- Join children's play as a guide on the side rather than a sage on the stage, or pair children who have complementary skills. Be attentive to what children are doing and noticing, and try interpreting their questions from their interactions with materials ("It looks like you're wondering how to change the shape of that shadow").