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Section 1
Paper-Copter Directions
Make a piece of paper twirl like the blades of a helicopter!

Directions:
1. Cut the paper-copter template into 4 individual strips by cutting along the thick black lines.

2. Using one of the paper-copter strips:
   - Cut along the SOLID LINES wherever the ๐ appears. (There are 3 lines to cut on: one long vertical, and two short horizontal ones.)
   - Fold along the DOTTED LINES.
     - Make the long folds "C" and "D" to form the base.
     - Fold up the small flap at the bottom of the base.
     - Lastly, fold along line "A" towards you, then fold along line "B" away from you to make the blades.
   - Put a paper clip at the bottom.
   - Hold your paper-copter up high and let it go! Launching tip: To get some extra height, try standing safely on a chair.

Change your paper-copter: Try new things!
- How can you change your paper-copter to make it fly better or differently?
- Can you make your paper-copter spin faster? Slower?
- Can you make your paper-copter spin in the opposite direction?
- Change the length or shape of the blades. What happens?
- How important is the weight at the bottom? Fly your copter without a paper clip. What happens? How does your copter fly if you put two or three (or even four) paper clips at the bottom?
Section 2
Science Process Skills in Early Childhood

Science process skills (also called Science Practices) are the skills that scientists use in the process of doing science. These are actually the same skills that we all use in our daily lives as we try to figure out everyday questions and interact with the world in a scientific way. Science skills are usually integrated together and used alongside one another.

**Observing**
Science begins with observation. It is the first and most fundamental of the process skills. Observing includes seeing, but also hearing, smelling, tasting, feeling (textures, temperatures etc.) and other sensory observations. By observing with their senses, children gather data about objects and phenomena. It is important to note that the ability to make good observations is essential to the development of the other process skills. Observations are often recorded through notes or drawings.

**Asking Questions**
Curiosity is at the heart of scientific investigations. Children are naturally curious and have a built in drive to ask questions to make sense of their world. With support from adults, children can begin to develop the skill of asking focused questions that allow them to proceed further with science investigations.

**Comparing and Contrasting**
Making observations naturally leads to making comparisons. Comparing and contrasting require children to sharpen their observations and to focus on details to identify similarities and differences. The process skills of comparing and contrasting are the basis for making groups and classifications.

**Classifying**
Classifying is the process whereby children group and sort objects, people or events. To classify, children make comparisons between objects, noting their similarities and differences. Young children can sort a set if objects such as rocks, leaves, seeds into subsets. They can sort by properties such as color, size, shape, texture, float/sink, magnetic/non-magnetic. Children should be given opportunities to group the same set of objects in different ways and to come up with their own criteria for sorting.

**Predicting**
Children make predictions when they formulate an idea about what they think will happen at a future time. Simple experiments involve predicting as children consider, "What would happen if...?" Predictions are based on observations and prior experiences. Predictions help develop awareness of cause and effect – “If we do..., then what will happen?”

**Experimenting**
Young children can conduct simple experiments to test out their ideas (hypotheses). In early childhood, experiments are often spontaneous, but as children get older, teachers can help them be more thoughtful about planning their investigations. Doing experiments introduces children to the process of making a hypothesis and of identifying and controlling variables. However, it is not reasonable to expect that children will be systematic in their experiments at a young age.
Using simple tools to observe and gather information

Young children can use real tools such as magnifiers, thermometers, eyedroppers or pipettes, tweezers, measuring spoons and cups, binoculars, rulers, and balance scales to expand their observations, to conduct investigations and to gather data. Make these tools part of everyday experience, not just during designated science times.

Measuring

Measuring is the quantification of a child’s observations through standard or nonstandard units. Young children can measure length, volume, weight, temperature and time. Standard units of measurement include inches, feet, pounds, seconds, minutes or days. Nonstandard units don’t require that children understand how to use measuring devices such as rulers, scales, timers, or calendars. Nonstandard measuring can be done using jumps, shoes, blocks, crayons, etc. In all cases, the items used to measure need to all be identical (e.g. brand new crayons) so that the unit of measurement is consistent.

Drawing Conclusions

Drawing conclusions is about processing and interpreting observations and results from experiments. Since young children’s preliminary conclusions are based on their own often-limited personal observations and prior knowledge, their theories are often incorrect. It is generally better not to correct their misconceptions by giving them an “adult explanation” unless you feel they are really ready. A concept may take years to develop and there is no hurry. Instead, continue to encourage children to share their explanations. Provide additional learning experiences to scaffold the child’s growing understanding and development of the concept.

Communicating

Communication requires a child to gather information, process it, and then present it so that others can understand his or her meaning. Children can communicate their observations, ideas, and conclusions by talking or writing, visually in drawings and other art media, or through dramatic representations.

Using and Creating Models

Scientists use models in many ways to help them communicate their ideas, and to understand processes. A model makes something simpler or easier to see that cannot be observed firsthand. For example, a globe is a model of the earth. Every model is like the real thing in some ways and different from the real thing in some ways. Models can help children study something that cannot be observed directly. Children can also build their own models of things such as a tree, a rocket, a bee, or a flower.

Note: There is no definitive list of science process skills for early childhood. Depending on the source, process skills are listed and described differently according to how they are interpreted. Some sources combine skills into broader categories with subsets, whereas others list them in more narrowly defined terms. This list was compiled using the following resources:

Making the most of water play

Sandra Cresser, Ph.D.

Puddles, spray bottles, garden sprinklers, and wading pools bring back gleeful memories of childhood. Even now, driving home after a rain, I secretly anticipate splashing down the little lane that the children and I have nicknamed the "puddle road." It is simply fun to play in water.

Early childhood educators have traditionally capitalised on the child's natural affinity for water play by including it as a centre in the classroom and by featuring it outdoors in warm weather. However, with the recent emphasis on academics typified by workbooks and cito sheets, water tables are becoming an endangered species, and in too many programmes children spend much less time outdoors than they used to. Perhaps it is time to look a little closer at the nature of water play and the potential it holds for engaging young children in meaningful learning.

Water is one of the basic raw materials for purposeful play. Just like sand, clay, and blocks, children can use water without being constrained by the one, right way to use it. Unlike many of the commercially produced, flashy playthings tempting us between Saturday-morning cartoons, water is a plaything that fosters curiosity, imagination, and experimentation—and it is free.

In the early childhood setting or outdoors, a water centre can be the catalyst for building concepts, developing language, and promoting social skills. Water play is developmentally appropriate regardless of the child's physical condition, age, language, gender, culture, or exceptionality (Bredekamp 1987). Water is intriguing. It seems to draw children to explore its structure and properties. Because water is naturally fascinating, the thoughtful teacher can structure the environment and materials in the water centre to make the most of water play.

What can children learn from water play?

Thoughtfully prepared, a water centre, whether indoors or out, can foster cognitive development, teach mathematics and science concepts, enhance physical skills, promote social learning and cooperative effort, and enrich language experiences.

Cognitive development. Modern cognitive psychology holds that children have a drive to make sense of their world (Plaget 1984). Given ample opportunities to manipulate materials in the environment, children build mental maps or frameworks through which concepts are developed. Furthermore, children assimilate new information into existing mental maps to refine and extend the concepts they have built (Wadsworth 1989).

When new information does not fit into an existing framework, the structure must be adjusted to accommodate the new input. This lack of fit is very important for teachers because, for us, it means that puzzling, novel situations can promote learning. For example, a child playing with a variety of objects in water might come to the mistaken conclusion that heavy objects sink and light objects float. The child has built incomplete mental maps for the concepts, "objects that float" and...
“objects that sink.” If that child comes across an object that is heavy and also floats, such as a log, she will experience disequilibrium — cognitive dissonance — clashing beliefs. Because a heavy object that floats will not fit in the child’s mental framework for floating and sinking, the child will be challenged to adjust her thinking framework.

Without the time and opportunity for lots of exploration, a child formulates fewer meaningful concepts. While water play promotes problem-solving and thinking skills in general, it is particularly well suited to the development of concepts in mathematics and science.

**Learning mathematics.** Depending on which materials the teacher selects to incorporate into the water center, specific mathematical concepts can be built. The following list contains a sample of mathematical concepts that can be built through water play. You and the children will think of even more.

- empty/full
- many/few
- before/after
- thick/thin
- more/less
- same/different
- heavy/light
- shallow/deep
- greater/less than
- sets
- classification
- rational counting
- liquid measure
- ordinal counting
- linear measure

**Learning science.** Water play leads children to ask questions (Chaille & Britain 1991). What does it do? How can I change it? Curiosity leads to experimentation, which provokes even more curiosity and more questions to challenge and intrigue. Children engage in both inductive and deductive thinking as they explore the properties of water. Inductive thinking uses facts and concepts to build a generalized conclusion. Deductive thinking is inferring the particular facts and concepts that support a general principle. Concepts can be built about force, energy, properties of liquids, states of matter, displacement, surface tension, pollution, solutions, and ecology.

**Learning physical skills.** Physical skills are developed through use. A water-play center promotes use of both large and small muscles as well as the skills needed to coordinate eye and hand movements.

Children use large muscles as they lift buckets and heft big sponges while they fill, empty, and clean up the water area. Short-handed mops for cleaning up drips and splashes also enhance large-muscle development.

Eye-hand coordination is practiced as children retrieve objects with tongs, aquarium nets, scoops, and fingers. Hand whisks, bastling bulbs, and egg beaters require coordination and are fun to use.

Small muscles get a workout as plastic tubes are fitted to funnels, medicine droppers are manipulated, water is poured from container to container, squeeze bottles are explored, and sponges are wrung dry.

**Learning social skills.** Water play may be solitary, parallel, associative, or even cooperative play with a group goal. The form of play depends on the felt needs of the children involved at the time. Whatever the form of play, children have many opportunities to find out what happens if sharing of materials and ideas takes place. Even solitary play requires consideration for the needs of others.

**Learning language.** When children play, they use and learn language naturally. Words such as sieve, funnel, surface, whip, flow, slot and strain enrich the young child’s vocabulary and allow him to express himself more explicitly. Positional words (beside, above, next to, etc.) and words that express relationships (larger, smaller, last) grow naturally out of water-play experiences. Children learning English as a second language particularly benefit from the language interaction that flows when children work either together or side by side.

In addition to the benefits of oral language development, water play can be extended to meaningful written language experiences. As children make and check their own predictions, they can be encouraged to record them. In this way children learn that print can function to help us remember or to convey information. Print is also useful in labeling objects or telling the story of a sequence of steps.

**How can I set up a water centre?**

Indoors or outdoors, a water-play centre can be as simple or elaborate as budgets permit. Commercially made tables are available for water only or for water and sand combined. Covers are usually optional. Most water tables come with drains for ease in emptying; but, because the plugs do not always maintain their seal after repeated use, some teachers prefer to empty the water by hand.

Carefully select materials to enhance water play with thought given to their potential for learning and of course, for safety. Equipment that has sharp edges or that might break or rust should never be used. Straws are potentially dangerous because very young children have a tendency to suck rather than blow into them.

Equipment that is frequently changed or modified renews interest and provokes divergent thinking. The list of items suitable for adding to water play includes common objects from school, home, and nature. You and the children will think of many more possibilities.
Practical concerns must be addressed as you plan the centre. Placement near a sink or tap is most desirable. A large sheet of heavy plastic will protect floor coverings.

Children will need plastic smocks or aprons to keep clothes dry. They can be purchased or easily made from oil-cloth or discarded plastic tablecloths.

Make cleaning up part of the learning experience. Children enjoy using sponges, rags, and short-handled mops to do "grown-up" work.

What is the role of the teacher?

To make the most of water play the teacher needs to be an enabler.

1. Structure the centre so children have interesting, challenging, and puzzling materials to stimulate their active play.
2. Sometimes, pose open-ended questions, engage in active listening, model the use of new vocabulary, encourage prediction, and thoughtfully observe what children do.
3. From time to time, debrief the children – give them the opportunity to tell others what they did and learned at play.
4. Occasionally help a few children evaluate their efforts and plan for what they can do tomorrow.

The teacher's role also involves communicating to parents the value of developmentally appropriate play (Taylor 1991). When parents ask "Do you teach them anything?" tell them about the marvellous things their children are learning at your water-play centre. Invite them to visit and observe for themselves the joy and satisfaction children exude as they learn about their world firsthand.

Water, perhaps our most abundant natural resource, should not be overlooked as a precious resource for learning in the early childhood classroom and in the early childhood out-door-play area. Water is not just for washing, and it is not just for ducks. Water is for children to enjoy and learn from!

25 ideas for promoting discovery learning in water play

1. Fill the water table with ice cubes, and provide shakers of salt and lengths of string.
2. Suspend a funnel low, over the water table.
3. Punch a row of holes from the bottom to the top of a 2-litre soda bottle.
4. Attach funnels to each end of a length of flexible plastic tubing.
5. Make it fruit day – provide a whole orange, lemon, lime, apple, grapefruit, coconut, mango.
6. Make it vegetable day – use fresh green beans, peas, carrot, radish.
7. Put salt in the water, then try to float and sink objects.
8. Substitute snow for water.
9. Place a large chunk of ice in the table. Provide safely goggles, rubber mallets, ice lolly sticks, and rock salt.
10. Provide lengths of plastic pipe, whole and also in sections cut in half lengthwise, to use as canals and ramps for rolling marbles, small toy cars, or blocks. Use the piping dry, then wet, and compare results.
11. Make a water lens by dropping water on newspaper that has been placed inside a zippered food-storage bag.
12. Punch holes in the bottom of milk cartons to make sieves. Use a variety of sizes of cartons and vary the size of the holes.
13. Give children heavy aluminium foil to shape into boats.
14. Suspend a pulley just above the water tables. Thread a rope through the pulley and attach a bucket to one end of the rope.
15. Offer a variety of cloth squares (canvas, oil cloth, cotton, leather, silk, nylon netting, vinyl, wool, polyester).
16. Experiment with all kinds of paper (blotters, newsprint, tissue, foil, waxed, corrugated cardboard, paper towels).
17. Add foam or rubber alphabet letters and small fishnets to the play centre. Name the letter you catch or catch the letters that make up your name.
18. Make number soup. Ladle up foam numerals. Order them, name them, see who can ladle up the largest, the smallest.
19. Experiment; with waves by making a wave machine. What do we need to do with a marble or ruler to make waves? How can we vary the pattern of the waves?

20. Sprinkle pepper on the water, then add floating bar soap.

21. Experiment with varying the amounts of water and air inside zippered sandwich-storage bags.

22. Try making a siphon with flexible plastic tubing and a bucket.

23. Predict which of a variety of seeds will float and which will not. Try out the predictions. Use nuts in shells, maple seeds, cottonwood, coconuts, buckeyes, and any others children can collect.

24. Challenge children to create a boat from found objects, then move it from one end of the water to the other without using their hands.

25. Challenge children to make a bridge over a portion of the water, using scrap materials.

**Water play enhancers.** Kindle interest and stimulate the imagination by changing water-play equipment frequently. Enhance play with objects from home, school, and nature:

<table>
<thead>
<tr>
<th>stoppers</th>
<th>soup ladle</th>
<th>bulb baster</th>
<th>slotted spoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>sieve/strainer</td>
<td>funnels</td>
<td>pasta</td>
<td>margarine tubs</td>
</tr>
<tr>
<td>film cans</td>
<td>ice lolly sticks</td>
<td>plastic ruler</td>
<td>cooking whisk</td>
</tr>
<tr>
<td>measuring cups</td>
<td>spoons</td>
<td>small pitchers</td>
<td>cotton reels</td>
</tr>
<tr>
<td>birdseed</td>
<td>cooking tongs</td>
<td>sponges</td>
<td>squeeze bottles</td>
</tr>
<tr>
<td>fishing bobbers</td>
<td>corks</td>
<td>scoops</td>
<td>Styrofoam meat trays</td>
</tr>
<tr>
<td>packing peanuts</td>
<td>rubber washers</td>
<td>medicine droppers</td>
<td>animal figures</td>
</tr>
<tr>
<td>seeds</td>
<td>aquarium nets</td>
<td>wood scraps</td>
<td>lids</td>
</tr>
<tr>
<td>empty spice tins</td>
<td>milk cartons</td>
<td>golf tees</td>
<td>ping-pong balls</td>
</tr>
<tr>
<td>latch-hook not</td>
<td>plastic people</td>
<td>bar soap samples</td>
<td>graduated containers</td>
</tr>
<tr>
<td>marbles</td>
<td>magnets</td>
<td>egg boaters</td>
<td>washing up liquid</td>
</tr>
<tr>
<td>food colouring</td>
<td>canning rings</td>
<td>buttons</td>
<td>foil balls</td>
</tr>
<tr>
<td>leaves</td>
<td>salt shaker</td>
<td>thermometer</td>
<td>feathers</td>
</tr>
<tr>
<td>sugar shaker</td>
<td>tennis ball</td>
<td>golf ball</td>
<td>plastic eggs</td>
</tr>
<tr>
<td>toy boats</td>
<td>rubber gloves</td>
<td>bottle brushes</td>
<td>spray bottles</td>
</tr>
</tbody>
</table>

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**Related products**
Sample Family Letter

Dear Families,

You may have noticed that your children are naturally curious about the world around them. They may be especially excited and interested in water, one of the most common elements in our world. Water not only offers rich opportunities for exploration, it is also part of children’s everyday experiences, whether they are taking a bath, watching rain as it drips down a window-pane, or playing at the water table.

As part of our science curriculum this year we are going to investigate water. Your children will develop a scientific approach to their investigation of water as part of small group water activities inside at the water table and outdoors (when weather permits). Through their water play, children will learn about important science ideas as they explore the properties of water and investigate how water moves.

At school your children will do the following:
- Pour, scoop, and squirt with various cups, bottles, basters, and eyedroppers
- Move water up and down using clear plastic tubes and funnels
- Examine drops of water
- Explore what sinks and floats
- Draw and paint pictures that show their ideas about water
- Share their thinking and ideas

Rest assured that we have very clear rules to ensure children’s safety. Although we provide smocks for children to wear as they explore water, please send an extra set of clothes for your child so that if he/she does get wet, we can help them change into dry clothes as soon as possible.

You can really help with our water exploration by encouraging children to explore water at home. Children will delight in exploring how water moves while in the bath or shower. And their experiences will be enriched when you provide plastic cups and empty shampoo bottles, so they can experiment with using different types of materials to move and control water. You can also help by thinking more about water yourself and by inviting your children to think about these questions with you. For example, you might think about how many ways you use water, where water comes from, and where water can be seen flowing or dripping. These discussions will promote your child’s curiosity and interest, while also helping children to think about water as a valuable natural resource.

We can also use your assistance and expertise at school. If you have time to volunteer, come help us as we explore. An extra pair of hands is always welcome. Or if you are knowledgeable about plumbing or anything else related to our study of water, let us know. We’d love to have you share your experience with all the children.

Water is wonderful! Dive into our study with us!

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Families Exploring Water

You and your child are around water all the time: in the kitchen, in the bathroom, at the beach, or in the rain. All of these experiences can present opportunities to explore water together. What’s most important is to try to maintain a positive attitude about water exploration, even when there is a strong possibility that water will make some things (and people) wet. By exploring water together, you and your child will learn more about each other and the properties of water.

Tips for Indoor Water Explorations
Children will delight in exploring the properties of water and how it moves while in the bath or at the kitchen sink. And you can enrich children’s experiences when you provide some of the following materials:

- Different sizes and shapes of clear plastic containers to invite filling and emptying.
- Empty shampoo bottles with small openings to help children focus on squirting and the drops themselves.
- Turkey basters and empty plastic liquid soap bottles with pumps so children can explore ways to move water.
- Objects of different shapes so children can explore what sinks and floats.
- Clear plastic flexible tubes to encourage children’s investigation of water flow.

While at the kitchen sink or in the bathtub, encourage children to experiment to see how they can do the following:

- Use the materials to make the water move in different directions (up and down)
- Make the water go at different speeds (slow and fast)
- Explore which objects sink and which float
- Create bubbles
- Make a drop come out of the faucet
- Turn their water flow back into a drip

Tips for Outdoor Water Explorations
You can also extend your child’s investigation of water to the outdoors by taking a rainy-day walk. As you walk together, encourage your child to explore and notice the following:

- How puddles form on different surfaces (grass, sidewalks, leaves) and then disappear
- How drops drip down windowpanes or off of cars
- How water flows off roofs, leaves, tree branches, and umbrellas; water races down gutters, gullies, and streams
- How children can make some of the water stop flowing or change its direction

Tips for Water Talks
As your child explores the properties of water, how it moves, and how air behaves in it, use these tips to get the water talks flowing:

- Talk with your child about how she uses the materials. (“The funnel is really helping you get water into that bottle!”)
- Ask open-ended questions. (“How did you get the water to move? How did you get the water to flow fast? Slow?”)
- Describe what your child does to move water or make it stop. (“Wow! You made the water gush really fast.”)
- Wonder out loud with children. (“I wonder what would happen to that bubble if you turned that tubing upside down?”)

Provide your child with the support she needs to share her thinking:

- Give your child time to think before she responds to your questions and comments. Silent time is okay.
- Find ways for your child to show you what she knows (for example, using the pump to show you how she can make water move up or down).

Avoid comments that could limit your child’s thinking. Avoid the following:

- Explaining the science
- Correcting ideas (rather, ask more questions)
- Moving on too quickly (allow the child to decide when to move on)

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Section 3
**Format of the Exemplar Activity Guides**

Each exemplar guide is designed to be an introduction to a science topic for young children. Each guide contains a materials list, easy to follow steps for setting up and facilitating the activity, suggested questions to ask the children, helpful teaching tips, and a background information section to support the teacher’s own science content knowledge. The exemplars are written in a step-by-step format to help teachers feel comfortable guiding the children’s explorations. However, the guides are meant to be flexible, like a basic recipe, that each teacher can modify depending on the interests, ages, and developmental level of the students. The guides are geared for children 3-6 years old. For some groups, the teacher may need to simplify the content and introduce fewer concepts, facts, and new words. Other groups may be able to handle more discussion and conduct more involved investigations. Ideas for further explorations are likely to emerge from the children’s experiences and questions during the exemplar activities. In this way, teachers can use the exemplars to lead into deeper and more ongoing investigations of a topic, rather than as “one and done” activities.

Each activity follows a consistent sequence, using the learning cycle process of Engage-Explore-Reflect. The chart below shows the intended purpose of each stage in the process.

<table>
<thead>
<tr>
<th>Learning Cycle Stage</th>
<th>Teacher</th>
<th>Learner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engage</strong></td>
<td>Introduces objects, events or questions to engage students; Accesses learner’s prior knowledge and related past experiences; Responds to learner’s interest.</td>
<td>Perceives and recognizes something of interest in the environment; Demonstrates curiosity. The more a learner is interested in a topic, the more they are motivated to be engaged and learn about it.</td>
</tr>
<tr>
<td><strong>Explore</strong></td>
<td>Creates the environment; Supports and enhances learner’s interest and curiosity; Encourages use of science process skills; Helps guide learner through thoughtful questioning to make their own discoveries; Observes and assesses learner; Respects learner’s ideas and encourages dialogue; Links new information to learner’s prior knowledge and previous experiences; Models use of new vocabulary; Takes note of what learner is most interested in, and expands upon that interest in further discussion and new explorations.</td>
<td>Actively explores objects and phenomena; Connects to prior knowledge and experiences; Collects further information using science and mathematics process skills; Raises questions, clarifies questions, shares ideas; Builds concept development and personal understanding.</td>
</tr>
<tr>
<td><strong>Reflect</strong></td>
<td>Facilitates “science talks” to help learner refine ideas, communicate, construct explanations and draw conclusions; Models and supports using scientific language; Asks more focused questions; Helps learner make connections; Helps learner plan further investigations.</td>
<td>Talks about what s/he did during exploration; Compares own thinking with that of others; Expresses observations, ideas, and understandings in a variety of ways, such as talking, drawing, journals, creative play; Practices using science language; Applies learning to new situations.</td>
</tr>
</tbody>
</table>
In this first-grade classroom there is lots of activity and children are involved in various learning centers. At one table are numerous wheels of different sizes and shapes made of play dough that the children made yesterday. One of them, Sarah, checks on the wheels she made, confirming that they have hardened. She takes her wheels and sits down at a table with a selection of straws and cardboard cartons of different sizes. After sorting through the cartons, she selects a small one and announces, "I'm going to make a funny car!" Sarah pokes straws through the holes in the cartons and makes two axles, then selects two round wheels for the front and two square ones for the back. As she moves the car around the edge of the table, she puts her fingers lightly on the back square wheels as they slide along the table surface.

Sarah stops her car abruptly and begins to smile. She takes off the two rear wheels and, after searching quickly through her pile of wheels, selects two egg-shaped ones and puts them on the rear axles. Now she rolls her car along the table and then on the floor, laughing and calling to the other children as it bumps along.
This activity is science education from a constructivist perspective. Why? Because it is providing children with a developmentally appropriate opportunity to engage in experimentation with the physical world. Sarah is self-directed, bringing her own ideas about movement to an activity that lends itself to many different types of experimentation. This experimentation is done in a context that both allows for and encourages social interaction; it lets children explore their ideas individually or cooperatively. These elements of the activity—self-direction and choice, social interaction, and active manipulation of materials—are congruent with the developmental needs and capabilities of the young child.

The constructivist perspective described in Chapter 1 implies rethinking the way we develop and implement curriculum. In this chapter, we will present a curriculum model that can help you to design activities that will generate the kind of experimentation illustrated by the above examples. We will then consider how to extend constructivist science across the curriculum, and how to link it with other curricular areas.

A curriculum model is a framework that enables the teacher to make decisions about what will go on in the classroom. It can help the teacher to choose materials, select and evaluate activities, and coordinate many different classroom experiences.

As we discussed in Chapter 1, a constructivist perspective focuses our attention on the child’s contribution to the construction of knowledge. Constructivism is based on the idea that children are actively engaged—naturally and without the aid of direct instruction—in building theories about the world and the way it works. From a constructivist perspective, children are natural scientists, and, given the opportunity, will engage on their own in experimentation and problem solving. The role of the teacher is to provide contexts within which such experimentation can occur and to facilitate theory building by providing helpful materials and experiences. The processes whereby children acquire and extend their understanding are of critical importance.

It follows, then, that a constructivist curriculum model should be derived from the child’s own thought processes and activities rather than from some content-oriented topic or theme arbitrarily chosen by the adult. And since children are viewed as actively inquiring natural scientists, our curriculum model should encourage experimentation. Materials and activities must allow for many possibilities. The curriculum model must provide guidance by creating learning situations that encourage a diversity of approaches. Such settings will
let children produce and test many different ideas and hypotheses, creating an environment that actively supports theory building.

Let's think more specifically about what this process of theory building looks like when children are engaged in an activity. Consider, for example, an activity that gives children the opportunity to combine materials. Let's think of an activity for 4-year-olds. Children come to a project table at which there are containers with different substances such as flour, water, sand, salt, and oil. There are also empty cups, spoons, basters, and medicine droppers. There are many ways in which the children can combine these substances and many ideas they can explore. A child can, for example, be interested in adding different amounts of water to flour, comparing the resulting differences in consistency. Another child could be engaged in exploring how flour combines differently with different liquids. Let's look at this activity as it is implemented in a preschool classroom.

Lucas, age 4, sits down at the table and looks at the containers of flour, salt, sand, water, and oil. He dips his finger into the flour, holds it up in the air, and blows on it. He laughs as the flour is blown off his finger and then dips his finger into the salt. He looks at it, noticing that nothing has stuck to it. Lucas reaches for the pitcher of water and pours some into an empty bowl. He sloshes his hands around in the water for a few minutes and then scoops a few spoonfuls of flour into the water, stirring it quickly around with a spoon. Focusing intently on his efforts, he lifts up spoonfuls of the mixture and, tipping the spoon, lets it drop back into the bowl. He repeats this a few times and then puts one hand under the dropping mixture and lets it fall into his hand. Laughing, he rubs his hands together with the mixture, holds them up in the air for another child to see, and says, "See my goop!" He then plunges his hands back into the liquid in the bowl.

Lucas adds more flour and then more water. He then repeats the pouring/feeling process. After working like this for a while, he dips his hands into a large bowl of plain water and swishes them around to clean them. He then dips his finger into the salt and inspects the salt-covered finger. He blows on the finger and notes that his breath does not blow the salt off. Then he dips his finger in water. Finally, Lucas takes another bowl and pours water into it. He begins scooping salt into the water, feeling the mixture with his hands after each addition.

Lucas is actively experimenting in a variety of ways with the properties of the different substances and combinations. If you look closely at his actions, you can see that he is asking several questions as he explores the materials. For example, as he puts his finger in various substances, he notices that some substances stick to his finger and some do not. Adding the flour to the water, he
explores the consistency of the “goop” and then experiments with what happens when he adds more flour and more water to the goop. Woven into this inquiry is the continuing question of what will stick to his finger, since he notices that when his finger is wet, things stick differently.

Lucas is posing his own questions, and his actions lead him quite fluidly from one experiment to another. Similarly, in the example at the beginning of the chapter, children are involved in constructing cars with different combinations of wheels and then altering them. Sarah plays with and compares the cars she constructs, experimenting with what happens when the wheels are of different shapes and asking how this affects the way the car moves. The combination of delight and seriousness of purpose that we see in both Sarah’s and Lucas’s experimentations is facilitated by materials such as these, materials that suggest experimentation and provide variety in a self-directed context. In both examples, children have many options for experimentation and can choose from a range of more or less complex concepts to experiment with, testing out many different ideas.

Now we have an initial idea of the overall goals of a constructivist curriculum model, and we are beginning to see what the resulting activities should look like. Our task is to provide a supportive environment in which children can ask their own questions and have the means to look for answers. The curriculum model itself reflects what we expect children to do when they engage in activities—it is based on questions.

These are not questions that teachers ask but questions that children ask as they engage in activities. If you try to look at the examples of activities we have given from the child’s perspective, you begin to see the different questions that the child is asking as he or she engages in experimentation. Some general categories of experiences begin to emerge. These categories are based on the particular elements of experimentation that the child is engaged in. We can put these categories of experience into the form of the question that the child may be asking. Going back to the example given earlier, of children engaged in constructing cars with different types of wheels and experimenting with the shapes and sizes of the wheels, the general question is “How can I make it move?” And where the children are engaged in combining different substances, the general question is “How can I make it change?” Such broad questions—“How can I make it move?” and “How can I make it change?”—can serve as organizers in curriculum planning. The activities that can be developed around these questions will be linked on the basis of the types of experimentation and theory building that the activities and materials will encourage.

In speaking of these questions as organizers of the curriculum, we are not referring to verbal questions asked by adults or children. Young children can demonstrate a great deal of understanding and inquiry without ever saying a
word! When Lucas was trying out different substances and exploring their various properties, he did not verbally ask the question “What is happening here? Is the salt sticking to my finger and the flour blowing off it?” Yet his actions, his repetitions and variations, and his intensity of interest are all indicators of active inquiry. Children do much of their most important work and play without saying anything about what they are learning.

Nor does a curriculum model organized around questions imply that teachers are asking questions of children. Quite the contrary! Teachers are creating activities and an environment that encourages inquiry—experimentation and theory building. The teacher’s role, after he or she has set up these opportunities, is to be an active observer and facilitator of inquiry but not to interject questions unless they are appropriate. We will have more to say about the teacher’s role later and will devote Chapter 4 to the techniques that teachers can use to decide whether and how to be involved. For now, remember that when we pose questions, we do not mean them actually to be asked by teachers or necessarily verbalized by children.

**Questions to Generate Experimentation**

In this book, we’ll be describing some general questions on which to base an early childhood science education curriculum from a constructivist perspective. The three questions we will focus on are:

1. How can I make it move?
2. How can I make it change?
3. How does it fit or how do I fit?

Each of these organizing questions corresponds to a primary category of scientific inquiry. “How can I make it move?” involves experimentation that explores some basic concepts in the area of physics; “How can I make it change?” explores concepts in the area of chemistry; and “How does it fit or how do I fit?” explores concepts in the area of biology.

“How can I make it move?”—our organizing question in the area of physics—incorporates a wide range of curriculum activities and materials that let children experiment with the movement of objects. Thinking about the different ways in which children could ask the question leads us to design different materials and activities. This, for example, the child could ask the question “How can I move it by tilting?” Following this, the child may construct and play with mazes that must be tilted in order to move a ball. This could provide an opportunity for experimentation with the underlying question. As
"How can we make it move?" reflects these children's experimentation with inclines and rolling objects.

Another example, the question of "How can I move it by rolling?" could be stimulated by providing an opportunity for children to experiment with balls and inclines. In Chapter 5, we will describe the curriculum that can be generated by using this question as an organizer.

"How can I make it change?"—the organizing question in the area of chemistry—underlies many of the young child's experiments. Transformation of materials characterizes much of the young child's spontaneous play. Children's interest in and active involvement with such materials as play dough and water, as well as their interest in construction toys, reflects the pervasiveness of this question. By designing materials and activities that encourage experimentation with transformation, we can facilitate children's theory building. Chapter 6 will describe some approaches to this curriculum area.

"How does it fit or how do I fit?"—the organizing question in the area of biology—explores what we call ecological perspective taking. How does the child perceive himself or herself in relation to the rest of the natural world? How do my actions affect the world around me? For example, how does the rabbit respond when I sit still and hold her in my lap: Is she calm and relaxed and not trying to hop away? Certain types of experimentation in this domain are often not possible or desirable; for example, we would not want children to see what happens if they screamed at the rabbit. In this domain, perspective taking is emphasized; this involves reflection on the possible effects of your actions on the world around you. Such reflection is facilitated
"How can we make it change?" is the prevailing question of these children's experimentation with tissue paper, glue, and water.

by the development of sensitivity, empathy, and appreciation for the natural world, including an awareness of transformations that occur there. This curriculum area will be described in more detail in Chapter 7.

△ How This Curriculum Model Is Different

The curriculum model presented above has a different focus than do some traditional approaches to curriculum development. There, curriculum in early childhood programs and early primary science education may be organized around content-oriented themes, or topics. Some content-oriented themes that might be familiar to those who work in preprimary programs are transportation, fall, and teddy bears. Likewise, in more traditional approaches to science education in the public schools and some preschools, familiar content-oriented themes might be matter and the weather. Such themes are derived from the content of the activities that are planned for children.

As an example of a traditional theme approach as contrasted with the constructivist approach, take the theme "dinosaurs" for a group of 4- to 5-year-old children. Activities planned for one or two weeks would be designed around that topic. For example, pictures of dinosaurs would be displayed
Being both attentive and gentle with the insect she has discovered is part of the curricular focus "How does it fit?"

around the room. Toy dinosaurs would be placed in the block area to encourage symbolic play. At the art table, dinosaur stencils might be made available. Books with dinosaurs in them might be selected for the library. Games such as lotto and puzzles that have dinosaur pictures might be put out in a game area.

To see how these activities can be linked only by subject matter, try substituting the word *vehicles* for *dinosaurs*; and you have the theme *transportation*. There is really no connection among the activities other than the particular content. From the child’s perspective, the activities are very different—not connected in any way except that there are particular images and labels associated with them.

This is not to say that the individual activities teachers might choose to go with content-oriented themes could not be enjoyable, developmentally appropriate, and even exciting. It is to say, however, that as a curriculum model, the use of content-oriented themes may not promote curricular integration and won’t focus the teacher’s attention on the child’s perspective. Instead, content-oriented themes make the teacher focus on the subject matter, which often reflects social arbitrary knowledge.

There are several important contrasts, then, between content-oriented themes and our question-focused type of curriculum development. First, in
planning a curriculum around the questions we have suggested, the teacher's attention is directed to the child's thought processes. It becomes important for the teacher to try to put himself or herself in the child's place so as to understand how the child will approach the materials and experiment with a particular activity. Thinking about the experimentation children can engage in helps us, as curriculum planners, to anticipate some of the many possibilities for experimentation and encourage the testing of hypotheses. In this way Sarah's teacher anticipated that Sarah might be interested in experimenting with the size of the car she was building. In order to make such experimentation possible, the teacher had different sizes of milk cartons available. In contrast, the content-oriented themes a teacher might choose do not necessarily encourage the teacher to see things from the child's perspective. Rather, the teacher turns to the topic itself for ideas: What do dinosaurs look like? What games use dinosaurs in them? Which books have pictures of dinosaurs?

Second, integration of the curriculum is achieved when one uses the curricular questions we have proposed—integration from the important perspective of the child. Presumably, the reason we have a curriculum model at all is so that there will be some coherence in what we do with children across time and across activities. In this case, the child's own activities and inquiry provide the continuity, not the adult-selected subject matter. An activity related to the one involving car construction would be to make available objects of different shapes and various inclines. Then, the children's experimentation would provide continuity with the other activity.

In contrast, a topically related activity might focus on the topic cars and the teacher might provide a collage-making activity, with pictures of cars available. The collage-making activity would be related to the incline activity only by topic and not by the child's actions.

WHERE DOES THE CURRICULUM COME FROM: OR, WHOSE QUESTION IS IT?

There is a good deal of confusion about the source of the curriculum and the relationship between children's interests and curriculum development. The common misconception is that, from a constructivist perspective, the curriculum comes from the child. In fact, curriculum is what the teacher plans, and may have many sources, including children's interests, but also including the teacher's interests, as well as the teacher's judgment about what will interest children. The important key to constructivist curriculum planning is to pay careful attention to the experimentation children engage in, and how they respond to activities and events regardless of where the idea comes from.

In fact, some of the most exciting examples of constructivist science have come about because of the interests and passions of the teacher who stimulates children's involvement in theory building around a question.
WHERE DO IDEAS COME FROM?

The question-focused approach to curriculum development is different from other curriculum models in that it takes as its starting point the questions children ask. However, it is not necessarily inconsistent with the views of those who have proposed the project approach to curriculum development, namely Katz and Chard (1989) and Gamberg and co-workers (1988). Nor is it inconsistent with the approaches to transformational curriculum taken by Rosegrant and Bredekamp (1992); integrated curriculum (Pappas, Kiefer, & Levstik, 1990); or emergent curriculum (Jones & Nimmo, 1994). But it does have a slightly different starting point in order to develop curriculum explicitly around the three traditional content areas of science. For all the good work that has been done in the arenas of language arts and reading (Wilde, 1992) and mathematics (Kamii, 1985), science is one curriculum area that is consistently downplayed in many early childhood classrooms. By directing attention to the questions children ask so naturally in science, we can better facilitate their interests and learning.

What Sorts of Questions Are Children Asking?

To look more closely at the continuity that this curriculum model brings to children’s experiences, let’s consider the kinds of questions children ask as they engage in such a curriculum.

First, note that the questions derive from the children’s own experiences and observations: “What will happen if I roll this ball down the incline?” “What will happen when I mix tempera colors into the play dough?” Because children experiment actively with the world and are keenly interested in observing it, they are open to all the events and occurrences around them, particularly when their actions are directly related to those events. This “sense of wonder,” to use Rachel Carson’s phrase (1968), is not just an openness to sensory experience but also involves the active processing of information. By directing attention explicitly to this sense of wonder, we can give children the support and encouragement, as well as more tools, for being the young scientists they are.

This sense of wonder is paralleled by a continual puzzling about what is experienced. Children are rarely satisfied with answers to their questions because their experience only serves to generate new ones. Just like the scientist who is never satisfied with an answer, the child continually searches for new knowledge and poses new questions. Each new understanding brings new things to learn, opening up new areas for exploration and experiment-
tion. Just as we encourage children to ponder, discuss, and read further in literature circles, we can encourage scientific theory building, in the ways described by Saul and her colleagues (1993) and Scott (1993), that is consistent with the constructivist approach taken in this book.

These two characteristics of young children—wonder and puzzlement—make theory building a process of continual ups and downs, successes and failures.

The experience of theory building and experimentation is delightfully rich and diverse. The teacher must be observant, insightful, and flexible in order to provide a stimulating and supportive environment. The remainder of this book is devoted to how these goals might be achieved, covering both the why, or theory, that underlies constructivist education and the tools the teacher will need to implement the theory in the classroom.
Section 4
The Value of Free Exploration

Free Exploration allows the child to...

⇒ do his or her own thing so later it will be possible to focus on the material as learning material. For example, if a teachers wants to use unifix cubes for a graph, they will be able to focus on the graph rather than on the particular qualities of the unifix cubes...how do they snap together? What do they feel like? Can you look through the hole? How many would it take to stretch to the wall?, etc.
⇒ Satisfy curiosity.
⇒ learn from other children.
⇒ discover a variety of possibilities with various materials.
⇒ have an opportunity to spontaneously discover sorting, counting, pattern, geometry, measurement, balance, comparisons of color, shape, size, weight, sound, etc.
⇒ work at his or her own ability level and feel successful.
⇒ experience the idea that there are no right or wrong answers.
⇒ verbalize ideas.
⇒ learn to share space and materials.
⇒ awaken his or her senses.
⇒ discover likenesses and differences in the world around them.
⇒ prepare the children for directed work with materials.

Free exploration allows the teacher to ...

⇒ observe the complexity of the task various children set for themselves and to observe how they react to difficulties in completing their task.
⇒ observe how the children interact with one another and the different materials.
⇒ observe what the children do spontaneously with different materials. (To observe children working with a material without the children trying to “please” the teacher.)
⇒ observe how a child learns through play.
⇒ observe which children are self-directed.
⇒ observe language patterns of children as they discuss with their peers.
⇒ have time to informally assess children’s skills.
Creating a Preschool Science Exploration Area

What are the goals of the science area?

- Reflect and nurture children’s interests.
- Promote an appreciation of nature and living things.
- Encourage children to manipulate and explore a variety of interesting materials and their properties.
- Allow children to practice scientific skills, such as wondering, observing, comparing, predicting, investigating, classifying, communicating, and recording.
- Provide practice with tools of science such as magnifiers, balance scales, thermometers, measuring tools.

Organizing Your Science Area: Where would be a good place to put your science area? What equipment and materials are needed?

Tips:

- Ideally, locate the science area in a sunny area of the classroom, with a low table and a shelf of materials that invite interaction from the children.
- Make the science area hands-on and interactive. Touching and exploring is to be encouraged!
- Provide materials that support open-ended exploration and problem solving.
- Invite children/families to contribute materials they find or bring from home.
- Involve children in labeling, charting and graphing.
- Change materials often, based on children’s interests, to keep things interesting.
- Always remember safety. Make sure all items are non-toxic.
- Observe and evaluate how children are using the science area and experiment with new ideas to keep it engaging.
- Make sure that you are integrating science into all the other areas in the classroom as well. How do the block area, art, dramatic play, and book area offer opportunities for science play and exploration?
- Many activities can be introduced at circle time and then be placed in the science area for children to explore later.

Materials:

- Ask for science material donations from parents of things they may have at home or obtain through their work.
- Have a special tray to display items brought in by the children.
- Keep materials well organized and in good condition.
- Rotate and change materials often.
- Materials kept in the science area should be integrated into other indoor and outdoor spaces too. Science exploration can occur in any area of the classroom.
Basic supplies
- Large and small magnifiers
- Binoculars
- Balance scales
- Tape measures and rulers
- Stopwatches and egg timers
- Mirrors
- Drawing paper, pencils, (crayons for drawing observations)
- Sorting mats and graphing grids
- Photos documenting children’s science activities

Nature and Animals
- Animal models and puppets (can represent themes such as insects, pond life, ocean life, reptiles, dinosaurs)
- Bug viewers
- Collections (see shells, seeds, feathers, gourds and pumpkins, tree items-acorns, pinecones, bark etc.)
- Specimens (discarded bee hive, animal bones, bird nests, preserved insects)
- Classroom pets (including short term visitors such as snails, ladybugs, caterpillars, tadpoles, ant farm etc.)
- Plants and planting experiments (growing seeds and bulbs, watching roots grow)

Physical and Earth Science
- Magnets
- Prisms
- Thermometers
- Color paddles
- Pulleys
- Gears
- Small machines to take apart
- Balls and ramps
- Wheels, gears, pulleys

Sensory Explorations
- Dry substances such as sand, cornmeal, dry beans, rice, (with funnels, scoops, sifters and containers)
- Water Play
- Playdough and rolling pins, cookie cutters, garlic presses
- Feely box
- Discovery bottles (children can help make these)
- Different fabrics
In early September, kindergarten teachers and parents noticed that children were very curious about rocks. Pockets and cubbies swelled with personal collections from the playground, the park, and other nearby outdoor places. Rocks and pebbles were exchanged like gifts, and crystals and fossils soon became classroom currency.

As they played, the children began to invent and develop a descriptive rock vocabulary to more clearly differentiate and communicate obvious and subtle differences. There were the sparkly ones, the marking ones, the volcanic ones, the ones that look like metal, the fossils, and the crystals. Then there were the kind that came from the fairies and even the ones from the moon.

Children asked each other questions based on their observations: How did you get that to be so sparkly? How do you think this rock was made? Where did you find that one? Thinking together in these ways helps children build deeper understandings and allows them to develop a scaffold on which to build more meaningful connections. By listening carefully to children as they ask questions and talk together, teachers can incorporate children's questions and interests into an inquiry-based curriculum that supports various types of learners.

**What is inquiry-based learning?**

Inquiry—investigating to gather information—is a part of human behavior from the moment we are born. Infants use all their senses—seeing, hearing, touching, tasting, and smelling—to explore and to collect information. Babies observe and turn toward faces, grasp at objects to put in their mouths, and follow objects with their eyes, all to gather more information (Thornton 2003). When a toddler repeatedly drops a ball into a tube and watches it vanish, he exhibits delight each time the ball disappears and then reappears somewhere else. It is as though he is wondering, "Will it
SUPPORTING ALL KINDS OF LEARNERS

What do you know about rocks?

Anna: If you see a rock that looks like it has a living creature in it, it is a fossil.

David: Some rocks are very sharp, and they can make a scratch on you. I found rocks that looked like metal. Another one looked like a crystal.

Allison: Rocks are very old. Some are millions of years old.

David: Can we study rocks?

What is a rock?

Brian: A rock is a little pebble.

Kate: Rocks are mostly hard things, and God made them and dropped them.

Bella: I think a rock is a part of the ground, but it broke...

Lily: ...Yes, rocks could have been little pieces of dirt from the ground that got really old—that got really smooshed together and then got hard.

What is sand?

Matthew: Sand is little tiny pebbles, little tiny broken-up rocks.

Grace: Sand comes from beaches.

Allison: Sand is from a volcano that exploded a long, long time ago—like fifty hundred years ago. When it got old from the volcano, it got cold and shrunk and then... sand!

Joe: Sand is something that is at the sea, and it came from the water. People get it from the beach and bring it to other places.

ASKING GOOD QUESTIONS

Every morning in our kindergarten we gather together in a circle to greet each other, share information, think about the day ahead, and discuss relevant learning experiences. After observing children’s play and their developing curiosity with rocks, the teachers decided to ask some intentionally crafted questions at a morning meeting: What do you know about rocks? What is a rock? What is sand?

Asking questions is a critical component of effective teaching. During children’s inquiry activities, a teacher’s skillful questioning fosters high-level discussions with the whole class, in small groups, or with individual students (Jacobson, Eggen, & Kauchak 1993). By asking open-ended questions and documenting children’s ideas—and revisiting their questions and ideas—teachers not only collect data from the children about which direction the project may take, they also address various learning styles. Teachers model reflection by reading back the thoughts generated during the discussion to the class. This allows the children to reflect and supports those who are more comfortable observing, those who need extra time to think, or those who are not always sure of the “right” answer.

The children learn what it means to answer an open-ended question: there are no right or wrong answers, all ideas are accepted, valued, and appreciated and become a part of the learning process. As children share, they become models for children with other types of learning styles, providing visual and auditory cues that inspire more inquiry.

Over the course of a school year, children of all abilities grow as contributing and valued participants in group discussions (YouthLearn Initiative 2001). For example, at the beginning of the year, one quiet, shy girl rarely raised her
hand or contributed to lessons or took part in group discussions. Even when her teachers encouraged her to participate, she would politely refuse. After about two months of listening to different discussions and watching teachers repeat and reflect the ideas back to the group without judgment, this girl raised her hand and shared her ideas with the class. Her contribution was welcomed with a smile from the teachers. After this initial sharing, she became more comfortable and began to participate regularly.

Another student was often the classroom “police officer.” He focused intently on classroom agreements and guidelines and followed them without deviation. He projected his strict adherence to rules onto his peers and expected the same behavior from them. This behavior often carried into group discussions. He valued facts and would often want to know the right answer to a question. Later in the year, as a result of our discussions about rocks and sand, we noticed that he began to accept and develop an appreciation for multiple perspectives and an understanding that for some questions there is more than one right answer.

**Investigating new theories outside of children’s prior knowledge**

Teachers and children looked closely at sand the children had collected from various places—the playground, a class trip to a local creek, and on family trips to the beach. They observed the sand with the naked eye and with magnifying glasses, and, using an overhead magnifying projector, they created an image that enlarged it more than 100 times its usual size. Children observed, documented, and discussed their findings in detail.

During the children’s investigation of rocks and sand, their initial questions were revisited, revised, and redefined by both the teachers and themselves. In the process, the children begin to make connections between rocks and sand. The focus of the study shifted and teachers shaped the curriculum to build on the children’s natural curiosities.
Reaching individual children

The teachers encouraged children to look closely, notice detail, pose questions, and reflect on what they learned. To guide the children's observation and support different learning styles, teachers asked children to draw and paint what they noticed when comparing and contrasting.

When it came time to mix the paint colors, a teacher asked one child with language and attention difficulties (and who was usually not interested in painting) to be in charge of the paints. The teacher explained that he would be the color captain and, with a small group of children, would be

Ways to Promote Inquiry-Based Learning in the Classroom

Ask questions that invite constructive input and validate prior knowledge. For example, instead of "Has anyone ever seen a rock before?" ask, "What do you know about rocks?"

Ask open-ended questions. For example, "Tell me about what you're wondering?" "What do you think might happen if...?" "What do you notice?"

Encourage children to wait a few seconds before giving an answer to allow time for thinking. Tell the children you are going to ask a question, but you would like them all to close their eyes and think about it for a few seconds before answering.

Repeat or paraphrase what the children say without praising or criticizing. This encourages children to think for themselves instead of seeking teacher validation. "Joe thinks that sand comes from rocks, and Andrea says it is dirt from the ocean. What do you think? Where does sand come from?"

What have you noticed about the sand?

Ethan: This is sand from a beach, and it has tons of crystals.
Anna: When I spread it out, there are tiny crystals, and it looks like cinnamon.
Jeremy: Some parts are big, like big rocks, and some are little like pebbles.

What did you discover about sand?

Allison: I discovered Abby's sand had millions and millions of crystals.
Joe: Sand has a lot of shells in it.
Nicholas: I found a crystal that curves. A curvy rock too.
responsible for mixing accurate colors to represent the sand. Taking his job very seriously, this child looked carefully at
the sand samples, communicated effectively with others, and stayed actively engaged in the project. “[Children] who
have trouble in school because they do not respond well to
lectures and memorization will blossom in an inquiry-based
learning setting, awakening their confidence, interest, and
self-esteem” (YouthLearn Initiative 2001).

In another example, two girls who exuded excitement
about rocks and sand walked around with pockets bulging
with their precious finds. Every day they both eagerly
shared their latest discoveries with the teachers. Simply
stated, they loved rocks. When planning the science inves-
tigation, the teachers kept the intense interest of these two
children—and their peers—in mind.

The teachers designed a chart that the children labeled
and used to organize and document their thoughts and
observations. Teachers set up tables in the classroom with
magnifying glasses and piles of rocks or sand that the children
had collected. When it came time to work with the
sand samples, one of the two girls squealed with excitement
and delight, “I see broken seashells and tiny rocks in my
sample!” All of the investigators came away proud of their
latest discoveries and eager to share their work with others.

Another child, creative and with strong verbal skills,
loved working with all forms of expressive media. He had
strong artistic abilities and a knack for designing and
building things with his hands. He had enjoyed the earlier
painting activities connected with the magnified sand but
was eager to create something new with rocks and sand.
To support his interest and to enrich the class project, the

teachers provided materials so the children could create
natural compositions out of rocks, stones, and sand.

The class traveled to the local supply store, where they
selected and purchased various types of rocks and sand.
Children used the large rocks to build temporary stone
sculptures that expressed ideas and feelings, such as “I
have been here” or “You are welcome” or “I am feeling very
happy today, and the sun is shining.” They designed natu-
ral compositions with the smaller stones and sands. Using
baby food jars, pastel chalks, and white sand, children
made the sand earth colors by turning and mixing each pastel
in sand-filled jars. Then the teachers and a small group
of children filled jars and other containers with all of the
materials to be used in the compositions. Children could
work and play with the materials by creating and erasing
and re-creating landscapes. During language arts, the
teachers asked them to note differences in texture, shape,
color, and size of the individual materials using descriptive
language.

This part of the project offered children with a keen
sense of aesthetics an open canvas on which to express
themselves. It also allowed children with other strengths
to explore an area of interest (rocks and sand) through the
language of art. As Wallace states, “When we use the pure,
simple materials of nature to create an expression of our-

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...selves, we can send a powerful message about our place in the world" (2004, 18).

Reflecting on the journey

Children's wonderings and reflections are essential to the learning process. Talking about their experiences with others allows children to articulate what they have seen or done in a way that makes sense. By listening to what others have experienced, children can understand multiple perspectives and reconcile these new ideas with their current knowledge. Listening to others' insights and opinions and learning that these are of value is a key skill taught in any inquiry-based classrooms.

Examining rocks and sand, noting differences and similarities, and talking with others about observations are all exercises in critical thinking. In his book *How We Think*, John Dewey defined critical thinking as reflective thought—an "active, persistent, and careful consideration of a belief or supposed form of knowledge in the light of the grounds which support it and the further conclusion to which it tends" ([1910] 2008, 6). Critical thinking involves children in the learning process by allowing them to probe and question while encouraging them to analyze and process the information through reflection and evaluation (Dewey [1910] 2008).

Throughout this project, children and teachers experienced rock and sand through many in-depth learning experiences—they collected samples, made observations, documented, counted, sorted, and classified. They created stories and wrote using descriptive language. Children built rock museums and invited friends to view the exhibits. They made artistic compositions using a variety of natural...
The children lived and breathed rocks and sand—they sang, danced, drew, painted, created, and designed with them.

Robert: It can be all different colors. The water rubbed the sand smooth.

Audrea: Sand from different beaches looks different.

Claire: When we look at sand, it looks fuzzy. It can be coral, broken-down shells, and crystals.

What other kinds of things have you learned?

Bella: We learned how to work together.

Allison: We learned how to take care of nature and that respecting the Earth is better for everyone.

Conclusion

When teachers design an inquiry-based curriculum grounded in documentation and reflection of children's questions and ideas, it can provide a scaffold to support many learning styles. "[While] the traditional approach is sharply weighted toward the cognitive domain of growth, inquiry-based learning projects positively reinforce skills in all three domains—physical, emotional, and cognitive" (YouthLearn Initiative 2008).

By building on children's prior knowledge and interests, teachers keep them motivated and engaged. As the Chinese proverb states, "Tell me and I will forget. Show me and I may remember. Involve me and I will understand."

References


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Chapter 8  Timely Questions

Questions make up a big part of our daily conversations at school and at home with families and friends. Good questions can promote observations and encourage children to share their ideas. A simple question such as “What do you see happening in the terrarium?” can focus attention on an important process that might be overlooked. A question such as “How are the snails and slugs similar?” stimulates children to compare and contrast the properties of organisms and objects. Questions can be powerful tools for stimulating children to think, describe, and ask questions of their own.

“What kind of animal is shown in this picture?” is a question that requires children to recall a specific piece of information. This narrow kind of question can be useful at the beginning of an activity to get children thinking about a topic that has been interrupted, or as part of a closing discussion to solidify vocabulary. Too often we overuse these “test-like” questions that...
require children to recite facts. Consider the following broader question: “What might happen if you put a tiny piece of paper in this spider’s web?” This invitation to speculate on spider behavior will stimulate interesting ideas and vocabulary. It has the added benefit of posing a problem that can be tested by the children.

**Divergent and Convergent Questions**

Questions can be *divergent* or *convergent*. Divergent questions, such as the spider web question, do not have one right answer but provide an opportunity for creativity, guessing, and experimenting. Divergent questions stretch children’s thinking:

- "What do you think?"
- "What did you find out?"
- "What might happen if?"
- "How can you make this object roll?"

Convergent questions ask for specific information, such as "How many legs does a spider have?" While these questions provide us with feedback on what children recall, when used too often, convergent questions can limit a child’s thinking and willingness to guess and experiment.

We gain valuable information by listening to children’s responses to questions—their ideas may lead an activity into new and interesting directions! The following are some techniques for using divergent and convergent questions productively:

- Ask questions that require more than a “yes” or “no” response. Compare “Have you seen a ladybug before?” to questions such as “Where have you seen ladybugs?” “What were they doing?” The latter questions invite the child to think about relationships and interactions between living things.

- After you ask a question, give the children time to think before taking responses. Wait a few seconds to give the children time to ponder and formulate their ideas.
• Ask children for their ideas about the subject. With the simple addition of the phrase "What do you think?" a convergent question becomes centered on the child's ideas and predictions rather than on a particular right answer. "What do you think will happen if we put this water in the freezer?" invites discussion in a more friendly way than "What will happen if we put this water in the freezer?"

• Ask questions with more than one answer and questions that promote investigation. This encourages many children to contribute to the discussion.
  "What kinds of animals might come to a pond for a drink of water?"
  "What do you predict will happen if we let go of this ball at the top of the ramp?"
These divergent questions encourage descriptions, comparisons, and predictions.

• Posters and drawings can become more effective teaching tools when used with a series of questions. Using the poster in *Ant Homes Under the Ground*, here are some convergent questions that could be asked.
  "What kinds of jobs are the ants doing?"
  "How many ants are walking upside down?"
  "What other kinds of animals are in the ant hill?"
  "Where is the largest ant?"

• While children are engaged with investigations, use divergent questions to find out what they are thinking.
  "Where have you seen ants?"
  "What might cause the ants to change their trail?"
  "What might happen if food is put near the ant hill?"
  "How do you think ants help the forest?"

Open-Ended Questions

Asking open-ended questions is a wonderful way for many children to respond without hesitation. Most everyone has an opinion when they are asked, "What do you like about ___?" or "Why do you think the worms moved to this end?" Sometimes we need to ask convergent questions that require a specific answer. Frequently children's responses are incorrect! Wrong answers should be acknowledged to support the child in his or her effort to respond. Restating the question may help redirect the child's thinking. "That's a good guess; let's look at all the ants again to find the biggest one."

All answers, correct and incorrect, are an opportunity for adults to evaluate children's understanding and experience with a particular topic or activity. Finding out why a question was answered in a certain way may be more important than the response being "right" or "wrong." Encouraging children to explain their reasoning, in cases of both "right" and "wrong" answers can provide important insight into their thinking, help identify misconceptions they may have, as well as help them improve their oral expression and ability to communicate.
Why Is the Sky Blue?

What about children's questions you can't answer? We try to be prepared, but youngsters frequently ask unexpected questions. If the scope of the question goes beyond your experience, tell the children that you don't know, and suggest ways you might find the answer together. Adults should not attempt to be the source of all answers, but instead should help children investigate their own questions. By presenting it as a "let's find out together" venture you are encouraging cooperation and teaching children to be resourceful.

The question "Why is the sky blue?" can be rephrased to promote an investigation. "What are some colors you have seen in the sky?" can be the starting point for daily observations and descriptions of weather. "What is happening when the sky isn't blue?" becomes an important and observable part of the child's findings. Many homes and schools have plastic prisms hanging in windows. These delightful light separators can become part of the investigation. Eventually "blue sky" will be just one part of a rich and tangible "Sky Study" created by the children.

By avoiding the complex physics explanation of blue sky, you teach children they can find out answers to things they wonder about. If you then decide to read an explanation of blue sky from a science book, present the information in a way that validates their findings as curious and avid young scientists.

Whenever possible, rephrase difficult "why" and "how" questions into ones that can be investigated by the children. Don't try to explain density to youngsters who ask "Why does this float?" Give them lots of different objects to test and ask questions such as:

"Which objects are floaters and which are sinkers?"

"In what ways are floaters and sinkers similar?"

"Can you make a sinker float?"

"Tell me what you know about things that float."

Children who play with and investigate objects in water will not understand and cannot explain the physics of buoyancy—the concept is too abstract. They will however become adept at predicting the behavior of objects in water, and their explanations about why they designed their boats in certain ways will be closely tied to their observations.

We invite you to take a closer look at how you use questions and the nature of children's responses. As you experiment with using questions that are open-ended and accessible to youngsters, you will gain insights into their reasoning.

Please see Resources Related to Questions on page 80 for helpful references on the productive use of questions.
Section 5
Sensory Experiences Can Be Messy Fun

By Angie Correll

Sticky, slippery, gooey, heavy, bumpy...that’s what sensory experiences are made of. Learning and retention improve depending upon how many of our senses are engaged. Many of our favorite memories involve multiple senses. When thinking about my grandma, for example, I remember the smell of the flowers in her garden; I can see her wearing her favorite outfit; I remember how her gooseberry pie tasted; and even how the sofa felt.

Sensory activities provide children with another meaningful avenue for learning. Sensory tables or several tubs rotated regularly with wondrous sensory materials are worthwhile investments for hours of learning, exploring, and fun. Because children learn best by having "hands on" experiences with materials, sensory experiences are vital to young children’s learning. Imagine trying to teach a group of four-year-olds about melting by having them watch an ice cube melt in your hand or as a grown up, learning how to use a new computer program without actually working on it!

While sensory materials are very rewarding for young children, they also present unique challenges for teachers. The rest of this article provides insight into the different types of learning that occurs during sensory experiences, activity and materials ideas, and practical tips for using sensory materials.

Cognitive Development

As children experiment with different sized containers in cornmeal or sand, they develop math skills such as size, conservation, counting, timing (how long it takes the sand to sift versus the dirt), matching (finding the same size or shape beans or buttons), and classifying and sorting (what are buttons, beans, macaroni). As children manipulate the materials, they learn to understand concepts such as more/less, full/empty and sink/float.

Science concepts such as cause and effect (what happens when water is added to dirt), gravity (water comes down the funnel not up), and solid to liquid (cornmeal and water mixture) are also explored.

Children have the opportunity to work on their problem-solving and decision-making skills as they determine how they are going to use the materials. For example, children decide how to build a boat that will float, how to turn the whipped cream green, or how to make the sand stick together.

Language Development

For children to appreciate and fully utilize their language skills, they must have experiences interesting enough to talk about. Sensory experiences are exciting because each child can use the materials differently. Children also develop pre-writing skills as they pour, spoon, grasp, and work on eye-hand coordination tasks as they use the materials.

Social and Emotional Development

Sensory experiences provide children with the opportunity to feel good about their decision-making skills - they control their actions and the experience. Self-discovery occurs as children become eager scientists. They take pride in their predictions, make observations, and respond to their findings. In addition, children learn to cooperate and work together around the sensory table. As the children work together or side-by-side, they learn to understand someone else’s viewpoint. The children also have the opportunity to express themselves and become confident in sharing their ideas with others. Children need an opportunity to try out their emerging concepts about their world in a safe environment as well as have an appropriate outlet for relieving tension. Pounding, squishing, feeling water through their hands are all ways of staying in contact with feelings while learning to control what he does about them.

Physical Development

Children reinforce and practice their small motor skills while pouring, measuring, stirring, whisking, and manipulating the materials. They learn to control their bodies and give their bodies directions to accomplish tasks as they explore. Gross motor skills are refined as children explore, usually outside, with running through a sprinkler, examining surfaces with hands and feet, or foot painting.

Creative Development

Sensory experiences provide open-ended opportunities where the process is more important than the product - how children use the materials is much more important than what he makes with them. Using creative thinking skills and expressing one’s creativity are important self-esteem builders.
Mediums and Materials
Supplies for sensory exploration are usually easy to gather and inexpensive. The following lists provide suggestions for mediums to fill your sensory table or tubs with and materials to add to the experience. Select items that complement your curriculum, are of interest to the children, and are safe for the age of the children involved.

Mediums
Water
Sand (dry and/or wet)
Dirt (dry and/or wet)
Cornmeal
Rice
Macaroni
Soybeans
Sawdust
Cornstalks
Dried beans
Fingerpaint with additives (sand, glycerin, sawdust)
Homemade sieves (poke holes in foam trays)
Fingerpaint in sealed plastic bags
Scents (almond or mint extract)
Shaving creme (not merthiolated)
Playdough
Clay
Confetti
Putty
Whipped Cream
Foam pieces

Materials
Basters
Whisk
Waterwheels
Ice cubes (add food coloring)
Tongs
Plastic tubing with stoppers
Aquarium rocks
Shaped sponges
Jelly worms (the kind used for fishing)
Seashells
Whipped soap flakes
Food coloring
Wooden blocks
Cooking utensils (measuring cups, spoons, funnels, etc)
Plumbers’ joints and pipes
Gelatin molds
Combs
Vehicles
Funnels and sifters
Different kinds of bowls and containers
Cardboard tubes
Plastic eggs
Buttons
Spools
Dollhouse furniture
Dishwashing detergent
Rocks and pebbles
Ping-pong balls
Straws
Pump and squeeze bottles
Corks
Wind-up bath toys
Buckets and pails

Recipes for Sensory Materials
Magic Goop
1. Mix 1 part cold water and 3 parts cornstarch with hands in the sensory table or bus tub.
2. If the mixture doesn’t dissolve in your hands, then add more water. If the mixture is too runny, add more cornstarch.
3. Store in an open container and leave to dry; the mixture will solidify. To use again, add water and mix to the desired consistency. It will last indefinitely when stored properly.

**Perfect Putty**

1. Mix 1 part liquid starch and 2 parts white glue. Experiment with the amounts until it reaches the consistency of putty.
2. The more glue that is added, the more flexible the material; the more liquid starch added, the more brittle the putty will become.
3. Refrigerate in an airtight container to store; it usually doesn't last more than a few days.

**Helpful Hints**

- Use a vinegar and water solution to quickly clean up shaving cream or try a large Styrofoam drinking cup - the shaving cream will adhere to the outside of the cup as you move it across the table surface in a circular motion.
- To avoid slippery and messy floors under the table, add an indoor/outdoor carpet or doormat a little bigger than the table. It can be rolled up and shaken outside for easy clean up and also dries easily.
- Plan to control the amount of mess (using a floor covering or smocks), leave enough time for clean-up and talk with the children ahead of time about the number allowed at the table at one time.
- Providing enough time, space and materials will help prevent a lot of problems and also encourage the children to be as independent as possible.
- Be certain that all materials are safe. Never use any breakable materials or items that present a choking hazard for children under the age of four.
- To optimize the learning experience, don't answer questions too readily. Encourage the children to experiment and find out the answer themselves or to get assistance from their neighbor.
- Carefully consider the use of foodstuffs (cornmeal, beans, macaroni, dried corn, etc.) as it pertains to your community. In some regions and cultures the use of food items as play materials may be offensive.

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Discovery Bottles

Each of the following projects requires a clean, empty plastic bottle with smooth (or minimally ridged) sides. Twenty-ounce bottles and smaller water bottles (like Aquapod) work well for most projects, though 20-oz. bottles are recommended for the three “waves” bottles. Where different amounts of ingredients are listed, the smaller amount is for smaller bottles and the larger amount for 20-oz bottles; however, feel free to experiment with amounts to achieve the effect you prefer. After adding the ingredients, screw the top on tightly. To minimize the risk of a bottle opening or leaking, either seal the top with a hot glue gun or secure it with duct tape. (If you’re not able to do this step at home, I can do it at school.) Make sure the effect is the way you like it before gluing or taping.

Swirling Colors Bottle

This is one of the more complicated bottles to prepare, but the mesmerizing swirl effect is well worth the effort. Slowly and carefully spray about ¾ cup foam shaving cream into a bottle. Add warm water until the bottle is completely full. Shake to incorporate the shaving cream with the water, and wait for the foam to dissolve. When two separate layers form (the top layer being cloudier than the bottom layer), add a little more water, allowing the excess to overflow into a sink. Keep adding more water, shaking, and allowing liquid to settle until all the foam is dissolved and you have a bottle of liquid without any layers. Add food coloring, and shake to incorporate the color. (The goal is to achieve a deep, rich color.) Allow mixture to cool. If, as it cools, you notice a white residue at the top, add more water, until the residue is gone. You will know the bottle was prepared successfully when you begin to see swirls of white in the colored liquid when you shake it. Note: The swirl effect may be unimpressive at first but will intensify over the next few days, as the color becomes richer and more pearlescent.

I-Spy Bottle

Begin by adding several trinkets to a bottle. (Some ideas to consider: a few alphabet beads, acorn cap, seashell, twisty pasta, K’nex or Lego piece, googly eye, elbow macaroni, die, button, paper clip, coins, marble, dried bean, popcorn kernel, Barbie shoe, heart bead, eraser, piece of chalk, small bell, pencil stub, rock, rubber band, tack.) Then fill 2/3 with rice or finch birdseed. (If you want, you can dye the rice beforehand using 1 part rubbing alcohol to 1 part food coloring.) Tape an “I Spy” list to the side of the bottle. Without looking at a list, children could write down the objects they find, or they could look at the list and try to find all of the objects. You could create a different kind of I-Spy bottle by putting alphabet beads into the bottle and seeing what words can be created from the visible letters. Or you could make an I-Spy bottle for a certain letter of the alphabet and include only objects that begin with that letter.
Density Bottle
Fill a bottle with shampoo. Add two or three marbles. Turn the bottle upside down, and watch the marbles slowly descend through the bottle. Notice how the marbles don’t descend through the liquid until the air bubbles reach the top.

Sparkling Waves Bottle
Fill a bottle ⅛ of the way with isopropyl rubbing alcohol (adult supervision required). Next, pour baby oil into the bottle within ⅛” of the top. Add two drops of green or blue food coloring, a few sequins and/or a few pinches of foil confetti (optional), and about a teaspoon of glitter. (White crystal glitter lends a lovely foam effect to the waves). Fill to the brim with more baby oil. Screw on the lid tightly. Turn the bottle on its side, and rock slowly back and forth to make waves (very relaxing!). Or shake the bottle for a different effect.

Alphabet Bottle
Fill a bottle with alphabet beads (about 50 for an Aquapod bottle or 100 for a 20-oz. bottle). Add a couple marbles, to break up the letters if they clump together. Fill with a 1” to 1½” layer of clear corn syrup. Flip the bottle upside down, then slowly rotate it on its side, to distribute the letters as evenly as possible. Flip it upright again, and watch the letters float down the sides of the bottle; name the letters or try to identify words.

Hidden Treasures Magnet Bottle
Fill a bottle half full of salt, sand or rice. Add small metal objects that will be attracted by a magnet (nails, paper clips, tacks, pins, screws, magnetic bingo discs, paper fasteners, jingle bells, etc.) and shake. Slowly drag a magnetic wand (available in the classroom) along the side of the bottle to uncover the hidden objects.

Glitter Bottle
Fill the bottom of a bottle with a ¼” layer of glitter. Add water, to the top off the bottle. Shake and observe what happens.

Kaleidoscope (or Stress) Bottle
Pour ¾ cup of clear corn syrup into a bottle. Add a small package of foil confetti, glitter (optional), and a few sequins (optional). Turn the bottle on its side, and slowly rotate it, to distribute the confetti and evenly coat the sides with corn syrup. Return the bottle to an upright position, and watch the confetti meander down the sides of the bottle. Or just keep slowly turning the bottle.
Magic Color Bottles
Fill three bottles with water. Add a few drops of red food coloring to one bottle, a few drops of blue food coloring to another, and a few drops of yellow food coloring to the third. Shake to evenly distribute the color. When you place one of the bottles in front of another bottle, you’ll see what new color is made (i.e. blue & yellow = green).

Sand Bottle
Fill the bottom of a bottle with about 1½” of sand (or colored sand). Add water nearly to the top. Shake and observe what happens.

Floating Magnets Bottle
In the party section of a store like Wal-Mart, look for colored magnetic bingo discs. Add about 25 magnetic discs to a bottle filled with water. Drag the magnetic wand (available in the classroom) along the sides of the bottle to pull the discs through the water.

Waves Bottle Variation 1
Fill a bottle 1/3 of the way with water. Add a couple drops of food coloring and a few pinches of crystal glitter (optional). Fill another 1/3 of the way with baby oil. Fill to the top with vegetable oil. Turn the bottle on its side, and watch the waves roll gently.

Waves Bottle Variation 2
Fill a bottle halfway with baby oil. Add water to fill ⅔ of the way. Add a couple drops of food coloring. Turn the bottle on its side, and watch the waves roll gently.

Bubble Bottle
Fill a bottle with 1” or more of water, a squirt of dishwashing liquid, and a couple drops of food coloring. Shake and observe.

Crayon Shavings Bottle
Put ¼ cup of crayon shavings into a bottle; then fill with water. Shake and observe.

Tornado Bottle
Fill a bottle with water nearly to the top. Crumple a few small pieces of aluminum foil into tiny balls. Hold the bottle upright, and move it vigorously so the top end makes a circle. (If the cap end were a crayon, you would draw a circle with it.) When you stop moving the bottle, watch the aluminum foil balls continue to move in a circular motion.

Find More Ideas at:
- Google search for “discovery bottles.”
Section 6
DAP Discussion Prompts

Keeping the principles of developmentally appropriate practice in mind, read the following prompts. As a group, choose one that you’re interested in exploring together then share your thoughts with each other. Move on to another prompt when you finish; you probably will not have time to discuss all three scenarios.

SCENARIO: USING FOOD FOR SENSORY EXPLORATION
Consider these different points of view about using food for sensory exploration:

A. “I don’t think that food should be used for play. We are sending children mixed messages about food when on one hand we ask them to eat what they take and not waste food, then on the other hand we let them paint with pudding mix, or put beans in the sensory tub and then throw it all away when we are done. Food is a precious resource, and many people are not lucky enough to have enough food to eat, let alone to play with. Food is seen differently in different cultures and playing with food may be offensive to some people. We need to teach children to be respectful of food and not wasteful.”

B. “I don’t agree that using food for sensory play and art is “wasting.” It’s being used, meaningfully and with great purpose. Are kids wasting colored rice? No they are using it in an alternative way. They are learning with it. It is valuable. I appreciate the need to be sensitive to families both socio-economically and culturally but I reject the idea that using food is waste. I do understand that it may be seen as a luxury to use food for play, but then surely having a huge variety of paper, handfuls of crayons and pens and many more craft materials could be considered a luxury too? Consider, too, that the bag of rice you buy in your developed world grocery store won’t otherwise be going to someone living in hunger.”

Discussion Prompt: How do these two different points of view relate to the core ideas of Developmentally Appropriate Practice?
SCENARIO: ARE DINOSAURS APPROPRIATE IN PRESCHOOL?

Leo was a new teacher at a preschool. At a staff meeting to plan curriculum, he mentioned that several of the children in his class of 4-5 year olds were really into dinosaurs. He suggested that they choose dinosaurs as a topic of focus. As a child, Leo had loved learning about dinosaurs, and as an adult, he was still a dinosaur enthusiast. He had lots of ideas for a project on dinosaurs with the students. As he started to talk about his ideas, another teacher, Gladys, cut him off saying that “dinosaurs are not developmentally appropriate for preschoolers.”

Discussion Prompt: Imagine you are another teacher at the meeting. Would you say anything? If so, what?

SCENARIO: DISCOVERY BOTTLES FOR DIFFERENT AGES

In this class, you have been introduced to Discovery Bottles and experienced their potential for developing young children’s science skills and knowledge. Think about your own experience making your discovery bottle and the examples shared by your classmates.

Discussion Prompt:
- What are the different ways a teacher could use Discovery Bottles with children from infants to first graders? What factors need to be considered?
- How would learning goals and outcomes be different for children at various developmental levels?
Key Messages of the Position Statement

The NAEYC position statement on developmentally appropriate practice reflects both continuity and change in the early childhood field. Still central since its last iteration (NAEYC 1996) are our fundamental commitments to excellence and equity in educating children and our core understanding of how children learn and develop. At the same time, new knowledge gained over the last decade has deepened that understanding, allowing us to revise and refine our ideas about how to promote every child’s optimal development and learning.

What is developmentally appropriate practice?

- Developmentally appropriate practice requires both meeting children where they are—which means that teachers must get to know them well—and enabling them to reach goals that are both challenging and achievable.
- All teaching practices should be appropriate to children’s age and developmental status, attuned to them as unique individuals, and responsive to the social and cultural contexts in which they live.
- Developmentally appropriate practice does not mean making things easier for children. Rather, it means ensuring that goals and experiences are suited to their learning and development and challenging enough to promote their progress and interest.
- Best practice is based on knowledge—not on assumptions—of how children learn and develop. The research base yields major principles in human development and learning (this position statement articulates 12 such principles). Those principles, along with evidence about curriculum and teaching effectiveness, form a solid basis for decision making in early care and education.

A call to reduce the achievement gap

- Because in the United States children’s learning opportunities often differ sharply with family income and education, ethnicity, and language background, sizable achievement gaps exist between demographic groups. Emerging early in life and persisting throughout the school years, these disparities have serious consequences for children and for society as a whole. Narrowing the gaps must be a priority for early childhood educators as well as policy makers.
- When young children have not had the learning opportunities they require in order to succeed in school, early childhood programs need to provide even more extended, enriched, and intensive learning experiences than they do for children who have had a wealth of such experiences outside of the program or school. The earlier in life those experiences are provided, the better the results for children. Parent engagement strategies, health services, and mental health supports are also critical.
Comprehensive, effective curriculum

- All the domains of children’s development and learning interrelate. For example, because social factors strongly influence cognitive development and academic competence—and the cognitive domain influences the social domain—teachers must foster learning and development in both, as well as in the emotional and physical domains.

- Effective, developmentally appropriate curriculum is based on what is known about the interrelationships and sequences of ideas, so that children’s later abilities and understandings can be built on those already acquired. At the same time, the rate and pattern of each child’s learning is unique. An effective teacher must account for all these factors, maintaining high expectations while setting challenging, achievable goals and providing the right amount and type of scaffolding for each child.

- Children’s learning experiences across the early childhood years (birth to age 8) need to be far better integrated and aligned, particularly between prekindergarten and K–3. Education quality and outcomes would improve substantially if elementary teachers incorporated the best of preschool’s emphases and practices (e.g., attention to the whole child; integrated, meaningful learning; parent engagement) and if preschool teachers made more use of those elementary-grade practices that are valuable for younger children, as well (e.g., robust content, attention to learning progressions in curriculum and teaching).

Improving teaching and learning

- A teacher’s moment-by-moment actions and interactions with children are the most powerful determinant of learning outcomes and development. Curriculum is very important, but what the teacher does is paramount.

- Both child-guided and teacher-guided experiences are vital to children’s development and learning. Developmentally appropriate programs provide substantial periods of time when children may select activities to pursue from among the rich choices teachers have prepared in various centers in the room. In addition to these activities, children ages 3–8 benefit from planned, teacher-guided, interactive small-group and large-group experiences.

- Rather than diminishing children’s learning by reducing the time devoted to academic activities, play promotes key abilities that enable children to learn successfully. In high-level dramatic play, for example, the collaborative planning of roles and scenarios and the impulse control required to stay within the play’s constraints develop children’s self-regulation, symbolic thinking, memory, and language—capacities critical to later learning, social competence, and school success.

- Because of how they spend their time outside of school, many young children now lack the ability to play at the high level of complexity and engagement that affords so many cognitive, social, and emotional benefits. As a result, it is vital for early childhood settings to provide opportunities for sustained high-level play and for teachers to actively support children’s progress toward such play.

- Effective teachers are intentional in their use of a variety of approaches and strategies to support children’s interest and ability in each learning domain. Besides embedding significant learning in play, routines, and interest areas, strong programs also provide carefully planned curriculum that focuses children’s attention on a particular concept or topic. Further, skilled teachers adapt curriculum to the group they are teaching and to each individual child to promote optimal learning and development.

- To ensure that teachers are able to provide care and education of high quality, they must be well prepared, participate in ongoing professional development, and receive sufficient support and compensation.
An Integrated Approach to Bubbles

Math

Science

Language

Gross and Fine Motor

Social/Emotional
Chapter 6

Cooking Transformations

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Cooking is one of the most popular and satisfying activities conducted in constructivist classrooms. It appeals to children’s interests, invites experimentation, and fosters cooperation among children. It also teaches children independent living skills; provides opportunities to integrate math, science, literacy, and social studies in meaningful activities that children find interesting and challenging; and fosters autonomy by allowing children to prepare and eat food in the classroom.

In this chapter we describe how cooking is typically presented in Classroom Types A, B, C, and D; discuss issues that must be resolved before bringing cooking into the classroom; and present seven principles of teaching illustrated with stories, primarily from a Head Start classroom. Finally, we describe how cooking provides opportunities to integrate across curricular domains.

COOKING IN CLASSROOM TYPES A, B, C, AND D

Although food and nutrition are important components of early childhood science curriculum, early childhood educators do not generally consider cooking itself as part of the science program. Many teachers, including those in Types A and B classrooms, tend to conceptualize science solely as content knowledge. Teachers in Types C and D classrooms regard science not only as content but also as a process of individual and cooperative hypothesis generating and testing, experimentation, and problem solving. Constructivist Type D teachers view cooking activities as opportunities to stimulate children’s scientific reasoning. The approaches to cooking typical of each of the four types of teachers are described in more detail below.

Classroom Type A

Cooking rarely occurs in Type A classrooms. Children in these classrooms study the food pyramid and learn about the variety of foods within different
food groups. For example, they may classify pictures of foods into the categories of fruits or vegetables. If cooking does occur, it is typically related to class parties or celebrations of special holidays and is not connected to the science curriculum. For example, children might be given the opportunity to decorate a prebaked gingerbread man with cinnamon candies or raisins at a winter celebration.

**Classroom Type B**

Teachers in Type B classrooms present cooking experiences as a product-oriented activity to be carried out mainly by the teacher. Although they may allow individual children minimal participation in carrying out the specifications of a batch recipe, such as adding one cup of flour to the bowl or stirring the ingredients, the teacher remains in charge of the activity. Science goals center around the nutritional aspects of food. In many Type B classrooms, teachers use cooking experiences as opportunities for children to address goals in other curricular areas such as following directions, engaging in sequencing activities, “reading” recipes, observing measurement activities, or addressing safety practices—goals clearly not related to the development of scientific understanding and knowledge. Frequently, cooking activities take on the flavor of an arts and crafts experience. For example, after reading *The Gingerbread Man*, children are instructed to replicate the teacher’s pattern of a gingerbread man by counting out three cinnamon candies for buttons, two raisins for the eyes, and one piece of licorice for the mouth. This objective centers on children’s counting skills and their ability to duplicate simple patterns rather than on the development of scientific knowledge.

**Classroom Type C**

Cooking serves a broad variety of functions in Type C classrooms. As in Type B classrooms, teachers use cooking activities to promote children’s understanding of nutrition and their ability to classify foods by food groups. Cooking opportunities frequently resemble arts and crafts activities, although children are provided more opportunities to make choices and express their individual creativity than children in Type B classrooms. For example, after reading *The Gingerbread Man*, children may be given the choice to cut out and decorate their own gingerbread man. Teachers in Type C classrooms initiate young children in food preparation through cooking experiences such as Ants on a Log, in which children fill celery sticks with peanut butter and place raisins on the top. As children carry out these simple preparations, teachers also introduce basic hygiene and safety measures to young children.

Teachers in Type C classrooms often see cooking experiences as opportunities to enhance and integrate academic areas such as mathematics and literacy. For example, the teacher may write and illustrate the recipe for **Ants on a Log**, and encourage children to count how many celery sticks and raisins they will need. Teachers in Type C classrooms see cooking as an opportunity for children to engage in hands-on activities in which manipulating and using real objects is considered sufficient for children’s development of knowledge. However, children’s understanding of the regularities and relationships that can be formulated through the process of cooking is not recognized or supported. Unfortunately, many cooking activities ignore the invisible aspects of chemistry that appear to young children to be magic. For example, when cooking muffins in the classroom, teachers fail to invite children to explore why some muffins rise and others do not. As a result, children cannot see the connections between their actions and the resulting products.

**Classroom Type D**

Constructivist teachers in Type D classrooms include cooking as part of the science curriculum. Like Type C teachers, they recognize how cooking provides multiple opportunities for integrating curriculum, for increasing children’s knowledge of food and nutrition, and for developing children’s awareness of the important hygiene and safety measures related to food preparation. Additionally, constructivist educators view cooking experiences as having potential for stimulating children’s scientific reasoning. Cooking activities are highly motivating to children and offer them real and purposeful opportunities to develop questions, test out their reasoning, encounter contradictions, and revise their ideas—that is, to construct knowledge. For instance, children have opportunities to notice what occurs when liquid is added to a dry mixture. Because the constructivist teacher does not insist that they follow the recipe, children may notice that their end product does not look the same as a peer’s. Teachers encourage children to focus on these invisible aspects of chemistry and attempt to identify what might account for the observed differences.

Gwen Harmon, a constructivist Head Start teacher, realized that her 3- and 4-year-olds did not understand why muffins “grew” in the microwave. To them it was magic. One day when they ran out of muffin mix (see Figure 6.1), she posed the following problem: “We have a problem because we have run out of muffin mix. Do any of you have any ideas about what we should do?” The children replied that they needed more “white powder.” They got a bag of flour from the pantry and proceeded to make muffins as they had in the past. However, the muffins did not “grow” and tasted terrible. Gwen
Muffin Mix:

- 8 cups flour
- 1 1/2 cups dried milk
- 3/4 to 1 1/2 cups sugar (see note below)
- 4 tablespoons baking powder
- 1 tablespoon salt

Mix everything together and store in an airtight container. Makes enough mix for approximately 45 muffins.

Muffin Recipe

- 4 tablespoons muffin mix (see recipe above)
- 3 half-tablespoons water (not 3 and 1/2 tablespoons!)
- 1 teaspoon oil

Put everything in a small bowl and stir lightly.

Pour into a paper cup.

Bake in a microwave oven on high for approximately 45 seconds (cooking times may vary).

FIGURE 6.1. Muffin recipe

asked if they had any ideas about how to make the muffins taste better. Over the course of the next few days the children suggested adding other white powders such as sugar and salt to the recipe and while the muffins improved in taste, they still did not grow. At this point, Gwen showed them a new white powder, baking powder. She explained that baking powder helps muffins to grow and added it to the children's muffin mix. As children made muffins that day they congregated around the microwave peering into the window. “Look, it's growing!” “Mine is getting big!” A few days later, children informed visitors to the class that it is the baking powder that makes the muffins grow. Although the children certainly did not understand all of the chemical interactions occurring as the muffins baked (neither do most adults), they no longer saw making muffins as simply magic.

BRINGING COOKING INTO THE CLASSROOM

Before introducing cooking activities in the classroom, several important issues must be considered. These concern the children's readiness for cooking, important safety and hygiene considerations, and other curriculum in place in the classroom.

Young Children's Readiness for Cooking

Even 3-year-olds can do some cooking, with support. Understanding what children are capable of doing will help when choosing appropriate recipes. Sometimes, young children are so fascinated with the ingredients of the recipe they cannot focus on the cooking aspect of the activity. A story from a Head Start classroom illustrates this point.

Near the beginning of the year, Christie Sales and her teaching partner, Gwen Harmon, were anxious to begin cooking, and chose the muffin recipe in Figure 6.1. At group time Christie demonstrated how to make a muffin. She showed the children (ages 3 and 4 years) how to measure by leveling off their measuring spoons with a wooden tongue depressor and how to measure and add water and oil without spilling. During the following few days, she sat at the cooking table during activity time, helping each child who chose to make a muffin. After witnessing successful muffin making and appropriate use of the materials, she decided to allow the children to make their muffins independently, with adults nearby to supervise the use of the microwave.

Checking in later to see how the muffin making was progressing, she noticed that few children were really measuring. Most children were just dumping ingredients in the bowl. Christie explained to Gwen that these were
beginning steps and that experimentation was necessary. She predicted that when the children saw the results—inedible goo—they would begin to follow the recipe. However, a short time later a classroom volunteer called her attention back to the cooking table where one child was holding the bottle of oil upside down and squeezing. The child watched, fascinated, while oil ran everywhere.

As Christie and Gwen reflected on the incident at the end of the day, they realized that the children were not interested in measuring. They were interested in dumping! The teachers decided to follow the children's interest and filled the sand table with flour, bowls, measuring cups, measuring spoons, spoons for mixing, and other large and small containers. The children flocked to the flour table. They made make-believe pies and birthday cakes and muffins. They poured and dumped and leveled. When interest at the flour table diminished, the teachers introduced the idea of making a papier-mâché piñata. They showed the children how to make paste using water and flour. The children experimented with different consistencies and figured out the logico-mathematical relationship that the more water they added, the runnier their paste became. Likewise, the more flour they added, the thicker it became. At this point the teachers decided that the children were ready to make muffins. However, they eliminated the oil from the recipe and made them only with muffin mix and water. The children continued to experiment, but they were no longer dumping. After several weeks, when they were confident of the children's ability to follow the recipe more accurately, they returned the oil to the recipe with great success.

Safety and Hygiene

As most adults realize, cooking exposes young children to potential dangers—primarily heat, sharp objects, and germs. As teachers, our task is to minimize these dangers so that children can safely engage in cooking. Safety and hygiene are excellent examples of content that is appropriate to tell children directly because this is not something they can easily discover on their own. Young children have difficulty understanding the necessity to wash hands, utensils, and cooking surfaces because germs are not observable, and neither are the effects of not adhering to good hygienic practices. It is possible to cultivate germs in culture dishes and thus make them visible to children. However, making a connection between germs in a culture dish and good hygiene practices for cooking is beyond the comprehension of most young children. They simply do not understand why they should wash their hands before cooking or refrain from licking the mixing spoon. Even when the teacher explains the rules, these injunctions may feel arbitrary to young children. The teacher must simply insist upon them as rules for cooking.

Safety rules must also be discussed with children and enforced, and teachers must arrange the cooking environment to be safe. Disposable plastic knives are surprisingly effective for cutting up fruits and vegetables (although no knife is totally safe). Microwave ovens are much safer than conventional or toaster ovens; consequently, when a recipe requires heat, we prefer using a microwave. Electric skillets can be used in early childhood classrooms with supervision, and can be made safer. Christie constructed a wooden frame that fits over an electric skillet so that when children inevitably rest their arm on the edge of the skillet, they do not get burned. One wonderful idea that came from a child is to use children's lightweight mittens as pot holders. They are the correct size for children and are readily available.

In addition to telling children the safety rules, teachers must provide supervision for all cooking activities that involve risk. In practical terms, this means that if one is introducing a new piece of equipment that requires close supervision at first (say, a blender), one should not have another activity taking place during activity time that also requires close supervision.

Concurrent Curriculum

Because cooking activities are extremely popular, it is especially important to provide an abundance of other interesting and engaging activities in addition to cooking. Otherwise, what happens is a crush of children all wanting to cook at the same time. This can be a disaster and can discourage even the most experienced teacher from ever again including cooking in the classroom. To avoid this, be sure that children have other activities to capture their interest while they are waiting for a turn at the cooking center. Depending on the recipe, this may also mean the same cooking activity will need to remain available for several days or even weeks until all children have had the chance to make it several times or until interest wanes.

PRINCIPLES OF TEACHING

We have synthesized our years of conducting and observing cooking activities with young children into seven principles of teaching discussed below.

1. Choose Recipes That Offer Something Challenging for Children to Do

To do this, one must have a good understanding of what the children are capable of doing and what they would find challenging. While recipes such as Cracker Spiders (a sandwich made with 2 round crackers and peanut
butter, with 8 pretzel stick legs sticking out)—a category we refer to as “cooking crafts”—are occasionally appropriate, they are generally challenging only to the youngest children. These recipes may serve other useful purposes such as providing children with the incentive to try unfamiliar and healthy foods. However, a steady diet of such recipes will not serve to promote the reasoning and construction of knowledge we have as our constructivist goals.

The general goal of constructivist cooking activities is the construction of physical and logico-mathematical knowledge. One must therefore make a thorough analysis of the recipes in order to understand what opportunities they afford children to construct regularities and relationships. As pointed out earlier, regularities are those things that always happen. They can be thought of as general laws. For example, heat changes things. This is true most of the time with cooking. Heat makes some things (such as eggs) harder, while it makes other things (such as potatoes) softer. Once they have noticed regularities, children can move on to construct relationships between what they do and the outcomes they obtain. For example, children have the opportunity to discover that the longer you cook an egg, the harder it gets. This is a cause and effect relationship between the length of cooking time and the consistency of the egg. Cause and effect relationships are at the heart of scientific reasoning.

One clue to selecting a recipe that offers opportunities for scientific reasoning is whether or not the recipe is foolproof. A recipe is foolproof when nothing in it varies. With nothing to vary, nothing can happen except what is predetermined, and therefore little reasoning is necessary. Recipes such as Cracker Spiders and Ants on a Log tend to be relatively foolproof. Generally, these recipes involve placement of uncooked or precooked foods in certain arrangements so that the food preparation resembles a craft activity rather than a cooking activity. Children have few opportunities to construct cause and effect relationships in these recipes.

2. Make Recipes That Children Can Read on Their Own

Recipes should be selected and designed so that children can follow them with little help from the teacher. Depending on the age of the children, this may mean creating recipes with illustrations and few words. The fruit smoothie recipe in Figure 6.2 is a very simple recipe that can easily be illustrated. As children become familiar and comfortable in “reading” recipes, the text accompanying the recipe may be lengthened. Repeated exposure to the same recipe assists children in recognizing words that regularly appear, such as cup, mix, and spoon, and for some children results in a base of sight words related to cooking. For younger children it is not necessary to label the cup as one-fourth cup. It can simply be represented as one small cup. As
3. Plan Cooking Activities That Mainly Can Be Done in Small Groups or Individually

Occasionally the teacher may want to do a whole group cooking activity such as making stone soup after reading the folk tale Stone Soup (Brown, 1947; Forest, 1998; McGovern, 1958, 1986). In general, however, it is better to allow children to work with one or two other children (or even alone). This way, they have more opportunities to be autonomous and experimental.

Children can also work in pairs to prepare food for the entire class. With the teacher, two children decide the day before what they want to prepare from a collection of familiar snack recipes; check to see if all of the ingredients are available; and, if necessary, make a shopping list for the teacher. The next day, they prepare enough snack for the entire class and serve it during snack time. This contributes to a sense of community as children take on the responsibility for providing food for their classmates who have a chance to express appreciation to the cooks.

Making individual portions provides opportunity to make comparisons between one's own and a peer's result. This helps children in constructing the relationships described above. An anecdote from Gwen's classroom provides a good illustration of the cooperation and learning fostered between children when they are allowed to cook side by side with little or no teacher intervention. From across the room, Gwen heard Chondra say, "You don't know what you are doing." She looked up and saw Chondra take Jerry's cup full of muffin batter out of his hand and pour it back into his mixing bowl. She stirred it until the batter was smooth and sticky, poured it back into the paper cup, and handed it back to Jerry who placed it in the microwave oven to cook. This may seem like an insignificant incident to a casual observer, but to Gwen, it revealed much about the two children and the success of her curriculum. It told her that Chondra knows a lot about making muffins and has made a relationship between the way the batter looks before it goes into the microwave and what it looks like when it comes out. She knows that if it goes in without being thoroughly stirred, it will not make a good muffin. This incident also showed Gwen something about how Chondra uses her language and social skills. Rather than taking ownership of his muffin, she handed it back to Jerry after she stirred it. This incident also says something about Jerry and his ability to see another child in the classroom as an expert. Jerry did not complain to the teacher, "She took my muffin," as might be expected from a child this age. Instead, he seemed to recognize her helpful intention and waited patiently while Chondra showed him how to improve his muffin. All of this occurred without any teacher intervention.

4. Do Not Insist That Children Follow Recipes Precisely

Another story about muffin making in Christie's class illustrates how deviations from the recipe can result in construction of knowledge. She always demonstrates how to make a muffin, but children frequently pay little attention to the directions and are inaccurate in their measurements. This often
results in mixtures with too little or too much liquid. When the mixtures have too little water, they are often very powdery and do not rise when they are cooked.

For several days Christie had been observing Jonathan make muffins. Every time, he either spilled most of the water out of his measuring spoon before adding it to the muffin mix or would not fill the measuring spoon all the way to the top. He would pour the crumbly batter into a paper cup, place it in the microwave oven to bake, and in 45 seconds remove a muffin that was no taller than it was when he placed it into the microwave. Finally, Christie said, “Jonathan, why do you think you always get such a short muffin?” “It didn’t cook long enough,” he answered. “Do you have any ideas about how you could make it taller?” she asked. “Cook it some more,” he said. Knowing that he would not believe her if she told him this would not work, she asked, “Do you want to try that?” He nodded, put the muffin back in the microwave, and cooked it longer. Soon the room was filled with the scent of burning. When Jonathan retrieved his muffin, it was almost black in the center. He looked at it dejectedly. Christie said, “I see you are upset. Were you surprised your muffin burned?” He nodded. “Would you like to try to make another one?” He nodded again. “You know,” she said, “I noticed that Lee makes really tall muffins. Maybe you could ask him what he does to get them to be so tall.” Together they went to find Lee. Lee consented to show Jonathan how he makes a muffin. A few days later Christie observed Jonathan making another muffin. He very carefully poured water into his measuring spoon, filling it all the way to the top. Then slowly he moved it over the mixing bowl and poured the entire spoonful into his muffin mix. It appeared that Lee taught Jonathan the importance of measuring accurately.

This story contains an excellent example of how a constructivist teacher respects children’s reasoning and fosters experimentation by encouraging them to try out their ideas. Jonathan had watched other children’s muffins cook in the microwave. He had observed that as they cooked, they grew taller. He concluded that the longer you cook a muffin, the taller it gets, and that therefore he needed to cook his short muffin longer. By allowing him to burn a muffin, Christie helped him to discover for himself that his idea was erroneous.

This story also shows how cooking can contribute to the sociomoral atmosphere by promoting cooperation among children. Rather than telling Jonathan how to make a tall muffin, she referred Jonathan to Lee. This accomplished several purposes: it strengthened the relationship between Jonathan and Lee; it showed Lee that the teacher recognized his ability to make muffins; and it showed both boys that children can be teachers too.

5. Allow Children to Make the Same Recipe Many Times

It takes a long time for children to become familiar enough with a recipe to begin to notice and make sense of the regularities and relationships embedded in the activity. This familiarity is also necessary for children (especially prereaders) to begin to “read” the recipe. The muffin recipe, for example (Figure 6.1), calls for 4 tablespoons of muffin mix, 3 half-tablespoons of water, and 1 teaspoon of oil. After children have had experience making muffins, they become aware of the variation in the spoons (large, medium, and small).

Because children benefit more from making a few recipes many times than from making many recipes once, this means that one need not invest in massive quantities of ingredients. A few basic ones are sufficient until children have mastered these and ask for more. Choice of particular recipes depends on the backgrounds of the children, the types of foods they are accustomed to eating, the foods available, and the budget. We have found that a good collection of recipes for a preschool or kindergarten class includes muffins, fruit shakes or smoothies, pancakes, French toast, quesadillas, dips (both fruit and vegetable), pudding, sautéed zucchini, glazed carrots, noodle soup made with ramen noodles, and oatmeal.

6. Encourage Children to Create Their Own Recipes

When children have become familiar with a few basic recipes, they can begin to suggest variations. For example, in Gwen’s classroom where the children had many experiences making banana yogurt shakes in a blender, the children decided they wanted to make a different type of shake. They had a class discussion in which they talked about several different options and decided on peaches. One child then suggested that they try ice cream rather than yogurt in the shakes; so they made a shopping list for the teacher, and the next day they made their peach shakes.

Sometimes children are simply curious about what will happen when they mix certain ingredients together. The results of these experiments are usually not successful from a culinary standpoint. This introduces the controversial subject of wasting food. For some people and some cultures, using food for activities other than meals is considered a violation of a primary value. If this is the case, then allowing children to experiment with combining and cooking different ingredients may not be appropriate. However, if wasting some food in the interest of education is acceptable, then allowing children to experiment with cooking different foods in different combinations can be fruitful.
7. Plan for Messes

Cooking generates messes under the best of circumstances. Add in young children whose motor coordination is not fully developed, and you have a recipe for possible disaster. This should not be a deterrent to cooking. Instead, the teacher can develop strategies for minimizing the mess, making clean-up go smoothly, and turning over responsibility for clean-up to the children.

Cooking is best conducted on a noncarpeted floor and, if at all possible, near a source of water. However, this is not always possible. Christie once taught 4-year-olds in a classroom without a water source. She used two small garbage cans with lids. She taught the children to fill one can by siphoning water from the sink in the bathroom and pulling the can on a cart into the classroom. The other can was for the dirty water. She placed the cans on either side of a small table and put a wash basin, a pitcher, soap, sponges, and towels beside the basin. When the children needed water, they used the pitcher to dip clean water and pour it into the basin. When they were finished, they dumped the dirty water into the dirty water garbage can. This system worked quite well.

Lots of cleaning supplies should be available to children—sponges, rags, paper towels. Diluted vinegar in a spray bottle is excellent for clean-up. It is nontoxic, cheap, and effective. A mop and bucket with a mop squeezer attached to it is invaluable for getting children to clean up floor messes and should be standard equipment in every classroom (not just for cooking). A mop handle can be cut off so that it is the correct height for children. Using the mop squeezer to squeeze water out of the mop is a physical¬knowledge activity in and of itself. Also, the children love it because it makes them feel grown-up.

INTEGRATING CURRICULUM IN CONSTRUCTIVIST COOKING ACTIVITIES

Many of the skills and experiences that occur as children engage in science activities also enhance children's development in other curricular areas. Specifically, cooking provides opportunities to integrate language arts, mathematics, and social studies (as illustrated by the content web for the muffin-making activity in Figure 6.4). For example, as children follow recipes, they have opportunities to read and make sense of the words and drawings. Oral and written language skills and vocabulary are developed as children express hypotheses, discuss their experiments, and compare their results. In relationship to mathematics, children read numerals, draw one-to-one correspondences between the drawings in the recipe and the materials, seriate measur-
Cooking provides reasons for children to engage in literacy behaviors across a broad range of developmental levels and meet literacy goals such as recognizing and writing their first names.

In Gwen’s classroom, children were highly interested in making muffins, and almost everyone wanted to cook daily. Since the cooking center could only accommodate a few at a time, children decided that a sign-up list was a fair way to determine who could be in the cooking center. Jerry, who loved to cook, became very motivated to learn to write his name so that he would have a turn to make muffins. Initially he always asked an adult to write his name on the sign-up board. Gwen routinely requested that he get his name tag so she would know how to write his name. They would look at his card and discuss the letters in his name and she would demonstrate how to make his J. By the next week Jerry could write his own J and his teacher would print the other letters. A few weeks later Jerry produced his name with only minimal assistance. In addition to writing their names, children in the class learned to recognize classmates’ names as they examined the list to find out whose turn was next.

One of the authors (Rebecca) who visited this classroom regularly would sometimes draw pictures or take photos of children during activity time. The children would label the pictured activities and write their names under the ones in which they had participated. This provided many opportunities to discuss the beginning and ending sounds of words and hypothesize what letters represent these sounds. For example, children labeled the cooking activity as “Making Muffins.” Darnell was quick to point out that both of these words began with the same sound. When Rebecca said “Mmm, What letter do you think makes this sound?” Bridgit knew that the letter M came at the beginning of both words. Very quickly children began to draw attention to other words in their environment that also had letters that were in their own names. Such recognition of letters and the sounds that they represent are critical relationships children must construct in literacy development.

Some children in the classroom made books about their cooking experiences. Bridgit selected photographs that had been taken while she was making muffins, determined the appropriate sequence of the photos, and dictated the following story.

Making Muffins

By Bridgit

First I put the muffin mix in my bowl. I stirred it. I licked the spoon.
Then I turned the page of the muffin recipe book. I count 1 2 3 4 as she points to the 4 tablespoons of muffin mix on the recipe.
I count 1 2 3 as she points to the 3 half-tablespoons of water shown in the recipe.
I put water in it. I put 5 chocolate chips in.
Then I put it in the microwave.
I took a lick but it was too hot. So I got a drink.
Then it cooled really really long. Then I ate it all.
The End

Bridgit wrote some of the words in her book and helped identify beginning and ending letters that occurred in many of the words that she dictated. When her book was finished, Rebecca pointed out that she had one word in her story that was also in her name and circled the it in Bridgit. She asked Bridgit if she could find that word in her story. Bridgit proceeded to locate each it in her story and place a circle around it. This activity marked the beginning of sight word recognition for her. Bridgit as well as other children who authored books about cooking read them to classmates and placed copies in the class library. These books became classroom favorites and facilitated development of individual literacy goals.

Mathematics

Cooking also offers opportunities to facilitate mathematical goals across a broad range of developmental levels. Measurement, a common goal required in cooking, was meaningful for some children in Gwen’s classroom, while other children were completely unaware of its role. Observations of two children, Emilio and Juan, exemplify the broad range of developmental levels observed in the class. Following the second demonstration Emilio attempted to become quite precise in his measuring. He carefully used a plastic knife to level his four tablespoons of muffin mix before emptying them into the small bowl for mixing ingredients. While measuring the required three
half-tablespoons of water, he first held the spoon above his mixing bowl. When he noticed extra water spilling into the bowl, he became more careful. As he measured his next spoonful, he moved his spoon so the extra water would fall on the table rather than in his mixing bowl. Juan, on the other hand, imitated the actions of measuring without understanding the underlying reasons. Juan would pull out a heaping tablespoonful of muffin mix, hold the spoon over his small mixing bowl, level off the extra mix into his mixing bowl, and then pour the remaining spoonful on top of that! When he measured the water he always added lots of extra water to the mix. In making muffins, he intended to imitate his teacher’s actions and those of his peers, but he clearly did not understand the logical reason for measurement. Inevitably, his muffins were very soggy and, according to him, not very tasty.

Operations such as addition and subtraction can also be integrated into cooking activities. The following vignette is a good example of such an opportunity. Bridgit and Summer, two good friends in the Head Start classroom, announced to Gwen they wanted to make a smoothie together. Immediately seeing the possibilities for mathematical problem solving in this situation, Gwen asked, “Are you going to make enough for one person or two?” The girls decided they wanted to make enough for two. “Well,” Gwen said, “this recipe is only for one person. So, how are you going to make enough for two?” She pointed to the first ingredient. “It says here you need one cup of milk. How many will you need?” Two,” the girls answered. With Gwen's support, Bridgit and Summer went through the remainder of the recipe, deciding how many of each ingredient they would need to make enough for two people. When they were finished, they set out two cups and divided the shake into two equal portions.

These early experiences in mathematics provide a foundation for later, more formal investigations.

Social Studies

As demonstrated in the above vignette, social studies topics (including social and moral development) naturally arise in cooking activities. Democratic process is an integral part of a classroom in which children have a strong voice in deciding how life in the classroom should be. For example, when the children in Gwen’s classroom decided to change the muffin recipe, they conducted a class meeting and suggested three possible new ingredients: strawberries, blueberries, and chocolate chips. They voted by placing their name cards under their choice. Chocolate chips won.

Cooking also provides opportunities for children to explore gender roles. Teachers can stimulate discussion by posing questions such as: “What kind of cooking happens at your house?” “Who does the cooking?” “Who cooks on the stove inside?” “Who cooks outside on the barbeque grill?” “Who cooks at the city’s summer celebration in the park?” Investigations can include visits to nearby eating establishments to meet the cooks. It is entirely possible during these discussions that a child in a preschool or kindergarten class might announce that boys do not cook. Experiences such as those described in this chapter can help to dispel these stereotypes.

Finally, cooking may lead children to question where different foods come from. Investigation of this question can lead to numerous studies such as where food is grown, the roles various people play in the production of food, and how food gets to our supermarkets. Field trips to grocery stores, farmers’ markets, and farms follow naturally. Because the questions are of genuine interest to children, they actively participate in identifying the answers.

CONCLUSION

Children are almost universally interested in cooking, and cooking provides them rich opportunities to be experimental. In this chapter we have attempted to show how to implement cooking activities so that they promote children’s scientific reasoning and cooperation. At the same time, cooking also provides opportunities to integrate the subject matters of literacy, mathematics, and social studies, and gives children opportunities to be self-regulating. It is our opinion that cooking makes an important contribution to early childhood curriculum and should be a part of every early childhood classroom.
 MAKING MIXTURES  
Child-Directed Explorations of Transformations

Flour and Oil  
Shaving Cream and Cornstarch  
Oobleck  
Invent Your Own Playdough  
Clean Mud
#1: Flour and Oil

Materials
For each person:
- 1 medium sized bowl
- 1-2 cups of flour
- Approximately \( \frac{1}{2} \) cup vegetable or baby oil (use vegetable if concerned children may eat it)
- 1 spoon

Other:
- Small containers for oil (or squeeze bottles)
- Extra spoons for scooping flour
- Newspaper or sheet to cover table
- Sponge and towels for clean up

Optional:
- Powdered tempera paint
- Glitter
- Small molds, such as condiment cups

What to Do:
1. Cover table with newspaper.
2. Before you begin, use your senses to observe and describe the ingredients. (With children, have them share prior experiences with the ingredients.)
3. Start with a scoop of flour in your bowl.
4. Add oil a little at a time. Mix well with spoon or hands.
5. Continue to add small amounts of flour and oil until ingredients are soft, silky and well mixed. You should be able to grab a chunk and mold it. If not, you may need to add more flour or oil.
6. Optional: Add powdered tempera paint and/or glitter.

Notes for doing this activity with children:
#2 Shaving Cream and Cornstarch
Each child can make their own mixture in a small bowl, or a group can work together to mix up a large amount in a big bowl or dish tub. This mixture can eventually produce a moldable dough.

Materials:
- 1-2 boxes cornstarch
- 1-2 cans shaving cream (unscented is best)
- 1 large bowl/dish tub (or small bowls for making individual batches)
- Liquid watercolors or food coloring
- Stirring utensils
- Newspaper or sheet to cover table
- Sponge and towels for clean up

What to do:
1. Cover table with newspaper.
2. Before you begin, use your senses to observe and describe the ingredients. (With children, have them share prior experiences with the ingredients.)
3. Color the shaving cream either in small bowls or in one large bowl.
4. Slowly add cornstarch and mix gently with your hands until the mixture looks slightly doughy. If you keep the dough on the wet side, it will be fluffier. The more cornstarch you add, the drier the dough. Be careful not to over mix.

Dispose of the mixture in the trash, not down the drain.

Notes for doing this activity with children:
#3: Oobleck
Each child can make their own batch of oobleck in a small bowl, or a group can work together to mix up a large amount in a big bowl or dish tub.

Materials
- Small pitcher(s) or cups to hold water
- 1 - 2 boxes of cornstarch (depending on size of group)
- Spoon for scooping cornstarch
- 1 large bowl/dish tub, or 1 small container for each child (such as small bowl or aluminum pie pan)
- Stirring spoons or popsicle sticks
- Optional: Liquid watercolors or food coloring
- Newspaper or sheet to cover table
- Sponge and towels for clean up

What to Do:
1. Cover table with newspaper.
2. Before you begin, use your senses to observe and describe the ingredients. (With children, have them share prior experiences with the ingredients.)
3. Pour cornstarch into bowl. Keep some in reserve in case you need to use more to adjust the consistency.
4. Add water a little at a time.
5. Keep stirring until it has a gooey consistency. You may want to use your hands.
6. Slowly add coloring, if desired.
7. If you want to make it thinner, add more water, and if you want it thicker, add a bit more cornstarch. The mixture should feel kind of like honey. You will have to experiment with more or less cornstarch or water.

Oobleck is a suspension, not a solution. The cornstarch does not dissolve in the water like salt or sugar would. This is why it is very important to not pour Oobleck down the drain. Should the suspension separate in your drainpipes, the cornstarch will harden and block the drain. Dispose of Oobleck in the trash.

Notes for doing this activity with children:
Recipe #4: Invent Your Own Playdough

Materials:
- Flour
- Salt
- Cornstarch
- Water
- Vegetable oil
- Optional: Tempera paint, liquid watercolors, or food coloring
- Bowls/containers to hold the ingredients
- Bowls for mixing (the size of the bowl will limit how much dough the children can make - large paper bowls work well)
- Measuring spoons of different sizes
- Playdough tools
- Newspaper or sheet to cover table
- Sponge and towels for clean up

What to Do:
1. Cover table with newspaper.
2. Before you begin, use your senses to observe and describe the ingredients. (With children, have them share prior experiences with the ingredients.)
3. Place the dry ingredients into bowls for sharing.
4. Place liquids into bowls or squeeze bottles. If using bowls, provide small measuring spoons for transferring liquids.
5. Give each child his or her own bowl to make their playdough.
6. Let children experiment mixing small amounts of the ingredients together to make their own playdough. As they mix the ingredients together, they can decide if they want to add more of a certain ingredient.
7. Provide tools such as rolling pins, cookie cutters, and plastic knives for playing with the dough.

You can store each child’s playdough in a zipper-sealed plastic bag.

Notes for doing this activity with children:
#5: Clean Mud

Have a small group of children work together to mix up a large amount in a big bowl or dish tub.

Materials:
- 1-2 bars of mild white soap (such as Ivory), or use soap flakes
- Old cheese grater
- 1-2 rolls of toilet paper
- 1-2 cups very warm water (best if warm enough to melt soap. Can use microwave to heat)
- Pitcher
- Large dish tub or very large bowl
- Newspaper or sheet to cover table
- Sponge and towels for clean up

What to Do:
1. Cover table with newspaper.
2. Before you begin, use your senses to observe and describe the ingredients. (With children, have them share prior experiences with the ingredients.)
3. Grate the soap and place a few handfuls in the tub. (Pre-grate soap for children.)
4. Add warm water to the tub and mix well.
5. Tear some toilet paper into small pieces, and add it to the tub.
6. Mush it all together for several minutes to combine all of the paper and soapy water until you have a smooth, slippery, pulpy, mess like the consistency of mashed potatoes. For the first couple of minutes it won’t feel like it’s really turning into anything, but be patient. Keep working it.
7. Because every brand of toilet paper is different when it comes to roll-size and paper thickness, you may have to add more water or toilet paper. You can make it into a moldable dough or leave it more like cool whip.

To reuse this mixture, leave uncovered in the tub. If it gets stiff and dry, reconstitute it with hot water. Dispose of Clean Mud in the trash, NOT down the drain.

Notes for doing this activity with children:
Section 9
# How Children Learn Concepts

<table>
<thead>
<tr>
<th>Naturalistic Learning Experiences</th>
<th>Informal Learning Experiences</th>
<th>Structured Learning Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td><strong>Definition:</strong></td>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td>• initiated spontaneously by children as they go about their daily activities.</td>
<td>• take place when a child is engaged in naturalistic experiences.</td>
<td>• preplanned lessons or activities in which the adult has specific learning objectives in mind.</td>
</tr>
<tr>
<td>• The child controls the choice and the action.</td>
<td>• adult recognizes an opportunity for a “teachable moment.”</td>
<td>• the adult chooses the experience and gives some direction to the child’s action.</td>
</tr>
<tr>
<td>• The adult’s role is to create a rich environment for play, exploration, and learning.</td>
<td></td>
<td>• can be done with individuals or small or large groups.</td>
</tr>
</tbody>
</table>

Example: *Child is playing outdoors on a windy day chasing leaves as they blow in the wind.*

Example: *Child is playing outdoors on a windy day chasing leaves as they blow in the wind. Teacher plays game of “I Spy,” giving clues about other things that are blowing in the wind.*

Example: *On a windy day, teacher brings materials outside for children to make kites out of paper bags and streamers. As they play with their kites, teacher intentionally draws children’s attention to the direction the streamers are blowing and connects this to the weather vane in the yard.*

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Section 10
Estimation Jars

Overview
Estimation jars challenge children to use mathematical thinking and reasoning abilities. They are fun, and engage children’s curiosity about numbers. The objective is to provide children with opportunities to sharpen their skills in estimating quantities. After children make their estimates, they count the objects and compare their guesses with the actual amount. The more they practice, the better they will become at estimating.

Materials
- A medium sized clear jar with lid
- Fun objects such as pom-poms, counting bears, Legos, uniform sized beads, poker chips, Unifix cubes, plastic eggs, marbles, corks, pasta shells etc.
- Writing utensils and paper for recording estimates

Getting Ready
Fill the plastic jar with items of your choice, but don’t mix items. For example, if using pom-poms, don’t put anything else besides pom-poms in the jar and use all the same size (different colors are fine). Avoid very small items.

Activity
1. Talk with the children about what is means to estimate (to make your “best guess”). Emphasize that it’s a guess, so it doesn’t have to be right. You might make connections to real life. For example, if you’re buying grapes, you probably wouldn’t count how many are in the bag. You would just estimate and guess if there are enough for everyone to share at snack time.
2. Show students the estimation jar you prepared. Ask them to estimate how many objects are in the jar. You might want to pass the jar around for them to hold and see up close.
3. Record their estimates (either on the white board or sticky notes etc.). Some children will be able to write their own estimate. Others will need an adult to write it for them.
4. When everyone has estimated, ask them to share how they came up with their estimates.
5. Post the estimates where everyone can see them. Talk about which estimates are the lowest and highest numbers. Depending on the group, you may want to have the children help you arrange the estimates on sticky notes from lowest to highest. Make observations about the estimates. Did some people estimate the same amount?
6. Count the objects in the jar together. Write the actual number where children can see it and compare it with their estimates. Talk about which estimates were closest.
Remind children that estimating is not about being right, it's about trying to make a close guess.

Suggestions

- You can do this activity with children as young as two years olds, but adapt it accordingly. With very young children, bigger objects are better and stick to 5 or fewer objects. As they get older, the items can be smaller and the amounts can be more challenging.
- Try using the same objects in a different container, or use the same container with different objects.
- Do a weekly estimation jar and set it up on a table where children can record their estimates on slips of paper during the week. Then, at the end of the week, as part of circle time, open the jar and involve children in counting the objects.
- Give children turns to fill the jar with classroom items or send it home each week with a different child. Provide a note to parents with directions, such as the example below.

---

**Estimation Jar**

Dear Parents,

Help your child fill this jar with something you have at home (cotton balls, bouncy balls, legos, dry pasta shells, unbroken crayons, ponytail holders, dog biscuits etc.). The objects must all be identical in size and shape, but can be different colors. As you fill the jar, count the objects with your child. Write the number of objects on a sticky note and put it on the INSIDE of the lid and close the jar.

Put at least ________ in the jar but no more than _________. The other students will estimate how many objects are in the jar. Please return the jar to school by _________.

HAVE FUN! BE CREATIVE!

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Principles of Counting

Learning to count meaningfully requires children to understand the following 4 key principles or “rules.”

1. The one-to-one principle means that each object to be counted must be assigned one and only one number name. Young children have a tendency to skip objects or to say two number words for the same object. Techniques for teaching this principle include reminding the child to count carefully and to touch each object with the finger. It is useful in the early stages for children to move an item out of the way as it is counted. A child develops an awareness of the importance of one-to-one correspondence by matching objects in everyday situations and realizing the importance of not omitting any item. For example, in setting the table the child provides a plate for mommy, a plate for daddy, a cup for mommy, a cup for daddy, etc.

2. The stable order principle means understanding that the counting sequence stays consistent. The number-name list must be used in a fixed order every time a group of objects is counted. It is always: 1, 2, 3, 4, 5, 6, 7, etc., not 1, 2, 4, 5, 8. Stable correct order is only meaningful if applied with one-to-one correspondence; it is not enough that it be memorized.

3. The order irrelevance principle means that the order in which the objects are counted doesn’t matter, the total will stay the same. The child can start with any object, and count them in any order. The order in which the objects are counted is irrelevant but all the objects must be counted.

4. The cardinality principle consists of the child’s realization that the last number word used represents how many objects are in the set. Regardless of which object is counted first or the order in which they are counted, the last object named always tells how many. A child who re-counts when asked how many candies are in the set that they just counted, does not understand the cardinality principle. To fully grasp this principle, a child needs to appreciate that the final number name is different from the earlier ones in that it not only ‘names’ the final object, signaling the end of the count, but also tells you how many objects have been counted; it indicates what we call the numerosity of the collection.
Math and Science in Preschool: Policies and Practice
by Kimberly Brenneman, Judi Stevenson-Boyd and Ellen C. Frede

Excerpt from the Preschool Policy Brief series from the National Institute for Early Education Research.

Connections Among Literacy, Mathematics, and Science

As researchers continue to explore the importance of specific science and math experiences and skills for school readiness and later achievement, we already know that early math and science experiences matter because they can support language and literacy development, independent of any effect on later math and science achievement.

Science and math interactions support vocabulary development by exposing children to a variety of new words in meaningful contexts. The practices of math and science are described using verbs such as observe, predict, estimate, sort, experiment, and so on. As children engage in these practices, they learn new nouns to label what they are observing—chrysalis, roots, seed pods, parallelogram—and use adjectives to describe attributes—sticky, dirty, roundish, pointy, more than, and less than. Research suggests that exposure to uncommon vocabulary words predicts vocabulary development, which predicts reading achievement, and that participation in sustained science experiences results in vocabulary gains for preschoolers.

Conversations about objects that are not present or events in the past or future support the development of abstract reasoning and are related to literacy skills. Such conversations often occur in the context of a science activity when children make predictions and plan explorations. Children who are asked, "What should we do to find out?" must use language to describe a plan for the future. When they are asked, "What will happen if...?" or "Why do you think seeds need water to sprout?", they are required to reason and talk about objects, events, and changes that they have not yet experienced. Similarly, explaining results and their causes supports the use of complex grammatical structures such as embedded clauses and prepositional phrases. Children's growing science content knowledge and their developing language skills mutually reinforce each other. Encouraging children to talk about their observations, thoughts, and reasoning as part of mathematical and scientific play helps them develop not just their facility with the language of mathematics, but also more general communication skills and their awareness of their own thinking.

Math and science explorations can be used to support literacy development. The content of fiction and nonfiction books can be scientific or mathematical and can serve as the basis for extended conversations between children and adults around key science and math content and ideas. When teachers create science charts to record children's observations, predictions, and explanations of results, they illustrate the links between spoken and written language and support growing print concepts. Producing simple graphs, recording numerical data on charts, and documenting how math problems were solved encourages children to use numerals or other symbols that represent number. Science journals can also be successfully incorporated into preschool activities as tools for supporting the growth of both science and literacy skills. A rich language interaction occurs as children watch their ideas and words translated into print as a teacher transcribes what children have to say about their entry. Recording in journals also provides opportunities for children to practice their own growing printing and spelling skills.
33 Conezio & French. (2002).
Section 11
Snack Time Math

Materials
Goldfish crackers (or other fish-shaped crackers)
One sheet of blue paper (8 1/2" x 11") per child
One paper cup (5 oz.) per child

Getting Ready
Fill a cup with fish crackers for each child and yourself.

Snack Time Math Game

1. Give each child a sheet of blue paper. Have the children pretend that the blue paper is a pond or ocean. What animals might like to eat fish? (Penguins, sharks, raccoons, bears, birds, whales, dolphins, sea lions, etc.)

2. Distribute the cups of fish crackers. Ask the children to pretend they are hungry animals and their crackers are fish. They can pretend to be any of the animals they came up with.

3. Tell the children a story similar to the one that follows. As you tell the story, invite the children to follow along and be hungry animals.
   - One day there were two fish swimming in the water. (Put two crackers on the blue paper to represent the two fish. Have the children each place two fish crackers in their "water").
   - As the fish were swimming, two more fish joined them. (Add two more crackers to the water.) Ask, "How many fish are in the water now?" [four]
   - As the fish were swimming, a hungry animal dove into the water and ate one of the fish. (Model being a hungry animal and eat one of the fish crackers. Have the children do the same.) Ask, "How many fish are left?" [three]
   - Two more fish joined the three fish that were left. (Add two more fish crackers.) Ask, "How many fish are there in the water?" [five]
• A very hungry animal dove into the water and ate four fish. (Have all the children eat four fish from their pond or ocean.) Ask, "How many fish are left?" [one]
• That one little fish joined three other fish. Ask, "How many fish are in the water?" [four]
• A hungry animal dove into the water to eat some fish. The fish got away! Ask, "How many fish are left?" [four]

4. The story continues with everyone adding and taking away - by eating - the fish. As you model the story, try to have the hungry animal eat various numbers of the fish, but not all of them. You can increase or decrease the numbers of fish depending on the abilities of your children. After the children are familiar with the way the game is played, they can take turns continuing the story, which helps develop their language and mathematical skills.

This activity idea could be used with different snack items as well. For example, use popcorn and pretend to be hungry birds! Be creative!
Introduction

In a preschool play yard nearby, Isabel is turning over the soil with a small hand trowel while Dylan carefully rescues worms and places them out of the way. Josie sprinkles birdseed on a patch of bare dirt and packs it down well, wondering what will grow from these mysterious seeds. Monica and Joaquin are playing intently under some bushes, with tiny people they have fashioned out of sticks and flowers. Today their teacher will help them harvest the sunflowers they grew, and show them how to eat the seeds and make the heads into natural bird feeders. Their chatter reflects the learning that is taking place. "I am going to grow corn so high, it will be up into the sky!" "Look, the water all went away into the dirt." "This plant is all dead. How come it died?" Without a lot of instruction, these children are exploring and discovering the natural world through a small patch of garden. They are making connections between the food they eat for lunch and the seeds they plant. They are taking care of a small piece of the planet and making it more beautiful.

The simple act of cultivating a garden can open up a world of growth, learning, and enjoyment. It also provides children with a delicious introduction to healthy eating. Children who garden love to "guess" on tomatoes, green beans, and carrots. Children are much more likely to eat vegetables when they have grown them themselves, and take greater pride in contributing to the family table or the classroom salad.

A garden for young people rarely resembles a typical adult garden. It might appear as small plots of earth with plants crowded in every which way. Plastic dinosaurs may creep through lettuce, nibbling as they go. Seeds often sprout up from the pathways where they've been spilled, and sometimes the plants that grow from them are the best in the garden. Leaves become blankets for dolls, and flowers become pots for miniature tea parties set among the bushes. The garden is a place for young children to play, to dream, to plant, to harvest and enjoy fresh produce, and to begin to know the workings of the natural world.

The Life Lab Approach to Garden-Based Learning

Life Lab is a nonprofit organization based in Santa Cruz, California. We have been bringing learning to life in gardens since the first Life Lab school garden was established in 1979. True to our roots, we continue to run year-round field trips and summer camps for kids of all ages at our Garden Classroom in Santa Cruz. We also support schools and organizations across the country as they endeavor to begin or enhance their own garden-based learning programs.

Our work is inspired by the hope that all children — whether from urban centers or rural communities — will have the opportunity to develop an intimate connection to the natural world and, specifically, to their own local environment. A preschool garden allows young children to watch a place change throughout the seasons, and even throughout the years. As students engage with this place, they develop a profound empathy and love for it, and a sense of belonging somewhere. As they watch a spider weave her web or warm up a worm bin with a blanket of fallen leaves, children take the initial steps across the divide that
often separates people from place. As our students grow into decision-makers in their communities and beyond, their empathy and love for the natural world will serve as a foundation for a sense of responsibility and a determination to act on behalf of the environment.

Since the goal of an early childhood education garden is to create a space for joy, exploration, learning, and connection with living things, it is not necessary that you have a "green thumb" to get started. In fact, gophers, weeds, and other factors that might be devastating to a well-manicured botanical garden or a production farm can provide some of the most exciting learning opportunities in a children's garden. In the garden, your job is not to know the name of every plant and keep everything in perfect order. Rather, it is to serve as a guide to the children, to help them get started and to keep them safe. Remember that the act of mucking around with soil, seeds, fresh air, and growing things is just as important as the final harvest. Along the way, seedlings may be eaten by birds, stepped on by little feet, or overwatered and washed away. If you can help turn these events into moments of discovery and learning, and can help the child get started again, you will teach a life-long lesson on how we learn and grow from our experiences.

One Life Lab teacher's best garden experience began when she said, "That bird must have been really hungry to eat all our baby peas! What can we do next time to protect them?" and let the students work together to create a barrier to protect their new baby plants.

Your students will have many questions once they begin their explorations. You do not need to have all the answers, just a willingness to discover along with them. Perhaps the best answer you can give to their gardening queries is "I don't know, let's find out together!"

Notes:
1For a summary of research regarding the impact of garden-based learning on children's academic achievement, nutrition, and social behaviors, visit www.cgan.org/research.php
Section 12
Germinating Seeds with Children

In every seed there is a tiny plant and food to help it grow. When a seed first starts to grow, it’s called germination. Germiration can be done without soil. These seeds can be planted in the soil after you are done with your observations in the cups and bags.

Materials:
- One sealable plastic bag or small plastic cup per child
- 1-2 Paper towels
- 1-3 Beans per child (such as lima, pinto, black, butter, or kidney beans)
- Water
- Tape and markers for writing children’s names on the cups or bags

Sealable Plastic Bag
1. Stack two paper towels on top of each other. Fold the towels in half and sprinkle them with water until they are completely moistened but not dripping wet.
2. Slide the paper towel into a plastic bag.
3. Space the seeds to the bottom of the bag so they are not touching and there is at least an inch of space around each seed.
4. Seal the bag closed to trap the moisture and prevent the towel from drying out.
5. Set the sealed bag in a warm area where temperatures are between 70 and 80 degrees. You may want to tape the bag to the inside of a window.
6. Check the seeds every two days until the seeds begin to swell and the first short sprouts emerge.

Plastic Cup
1. Crumple the towels and push them firmly into the plastic cup.
2. Wet the paper towels until they are completely moistened but not dripping wet.
3. Place 1-3 seeds around the cup between the cup and paper towel. Space the seeds so they are not touching and there is at least an inch of space around each seed.
4. Set the cup in a warm area where temperatures are between 70 and 80 degrees. Make sure that the paper towels remain moist, check daily to see if they need more water. You may want to cover the cup with plastic wrap and a rubber band to retain moisture.
5. Check the seeds every two days until the seeds begin to swell and the first short sprouts emerge.
6. If you covered the cup, remove the plastic wrap once the stem begins to grow.

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Seeds in the Window, Soil in the Sensory Table

Science Education through Gardening and Nature-Based Play

Alyse C. Hachey and Deanna L. Butler

Early in the school year, I realized that the 3-year-olds in my class had little exposure to nature and even less knowledge of things in nature. As a child, I spent a lot of time outdoors playing, hiking, and working in the garden with my family. These experiences gave me a continuing appreciation for nature of all kinds, and I wanted to offer my class similar opportunities. I wanted the children to listen to birds and to look at trees and really notice details about them. I wanted the children to be curious about insects, not frightened of them. I wanted them to experience planting a seed and watching it grow. I wanted them to help care for plants and notice the growth, the smells, and the textures of leaves. I wanted the children to first notice, then observe, then appreciate and question and wonder about these things...

A growing body of evidence indicates that contact with nature is as important to children as good nutrition and adequate sleep, and therefore, educators need to address children's access to nature (see Louv 2008 for a review). This is particularly important in urban areas, where children have few opportunities to interact with nature. Gardening and nature-based curriculum support children's development and learning in academic, social, and health-related domains (Ozer 2007). The National Research Council states, "Because plants are especially easy to grow and care for, students at every grade level should be involved with gardening projects, using outside space, window boxes, or potted plants" (NRC 1990, 14).

Gardening and nature-based play in preschool classrooms integrate motivating and meaningful activity with the three elements of science education—attitude, process skills, and content (NRC 1996; Charlesworth & Lind 2007).

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naeyc® 2, 3

Reprinted from Young Children • November 2009
Scientific attitude, process skills, and content

Building scientific attitude involves encouraging children's natural desire to question and seek answers. Gardening supports children's curiosity about and exploration of the natural world and provides opportunities to build self-confidence through successful nurturing of plants over time.

One day, Jack walked across the classroom with his hand full of something that was dripping water. When I asked him what he had, he opened his hand to reveal wet bean seeds that I had brought in for sorting. I asked what he was doing with them. "I want to make them grow. They need water, don't they?" he replied. Jack showed that he had ideas about what plants need and he was willing to try out his ideas. I suggested that we put the seeds in a damp paper towel in a plastic bag and hang it up near the window so we could observe what the wet bean seeds would do over the next few days.

Science process skills relate to how children find the answers they are seeking. Such skills include using simple tools like rulers and magnifiers to observe scientific phenomena and documenting findings through graphs and drawings. Children learn these skills through concrete problem solving and discovery that focus on inquiry. Gardens provide a workspace for children to raise questions about the natural world, take hands-on action, and seek answers through observation, exploration, and data collection.

I brought in samples from my fall garden and added them to the items we had collected in the neighborhood—leaves, dried bean pods, and other natural materials. The children observed the materials with magnifying glasses, sorted them, touched and smelled them, and played with them. Capitalizing on Jack's desire to make some seeds grow, we planted his beans, then observed and measured the growing sprouts. Jack's interest sparked the interest of the other children. They too wanted to put beans and seeds in plastic bags and then plant the sprouts. The children took measurements and drew pictures to compare their sprouted beans' growth.

Science content includes the facts, concepts, and models that we want children to know, understand, and use. The study of plants and nature allows

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Hang plants from the ceiling; place them on shelves and window ledges; use them to fill empty spaces on tables and furniture. Water them and sometimes commented on new leaves or a plant getting bigger. While watering a particularly colorful plant, one child looked at the sweater he was wearing, then looked at the leaves he was watering. He laughed and said, "Look, I look like the plant. Look, stripes [pointing to his sweater] and stripes [pointing to the plant]!" Both had stripes of the same colors.

I also brought in plants for the classroom. The children helped water them and sometimes commented on new leaves or a plant getting bigger. While watering a particularly colorful plant, one child looked at the sweater he was wearing, then looked at the leaves he was watering. He laughed and said, "Look, I look like the plant. Look, stripes [pointing to his sweater] and stripes [pointing to the plant]!" Both had stripes of the same colors.

When I asked the children what plants needed to grow, collectively they knew quite a lot. They said that plants needed sun, warmth, water, soil, and time to grow!

This type of curriculum does not have to be complicated or use extensive outside space to succeed. Urban schools or schools that have very limited green space outside can still offer gardening and nature in the classroom, as seen in the tips that follow. Successful gardening and nature-based activities depend on being thoughtful about the space in and outside of your classroom and seeking out readily available natural materials.

Gardening basics

Include a variety of plants to make the classroom warm and homelike and to spark children's interest in nature. Hang plants from the ceiling; place them on shelves and window ledges; use them to fill empty spaces on tables and furniture. Just about anything can be used to hold plants, but be sure to use containers (with holes for drainage) that are big enough to hold plenty of soil and water.

Child-friendly classroom plants include grape ivy, Christmas cactus, aloe, cast iron plant, spider plant, bamboo, and pothos—the last two can even grow in water! An Internet search of "easy-care indoor plants" will lead to detailed photos of plants and descriptions of their needs to help you select what will work best for your space. Aim for a variety of leaf shapes and textures throughout your classroom. Most important, do your homework. Make sure that all classroom plants are nontoxic and nonpoisonous to children. (For a comprehensive list of Web sites and books on this topic, see http://research.cals.edu/research/biol/biblio/biblio/poison.htm.)

A few pots on a shelf by a window can support yearlong gardening investigations. Focus on plants that do well in small spaces, have a short growing season, and are low maintenance. Several good seed choices for producing food are radishes, lettuce, spinach, carrots, bush beans, and sunflowers. Consider sprouting a pot of grocery store produce, such as garlic, potatoes, onions, and yams. In a container of damp soil, simply bury each item so that 1/3 is below the soil and 2/3 is above the soil. They will sprout quickly, have interesting stems and leaves, and can grow quite large!

For a wintertime planting project, look at local flower shops or grocery stores for paperwhite bulbs that are prepared specifically for growing indoors. Paperwhites grow very quickly once they begin to sprout, and they produce long-lasting, fragrant flowers. A wonderful accompaniment: to the growth and study of paperwhites is the picture book Paperwhites, by Nancy Elizabeth Wallace. Important note: Paperwhite bulbs can be mildly toxic to humans if eaten, so use care when planting them with children, and for extra safety, have children wash their hands if they handle the bulbs.

Place gardening containers in areas of the classroom that get lots of bright light yet are not too close to heating or air-conditioning sources. Use a high-quality container soil mix to ensure the best chance of success. Provide child-size gardening tools so the children can do as much as possible. Be sure to account for growth rates and how long a "growing season" you have, in terms of school days and vacation time, so the children get to care for and observe their plants' growth as much as possible. To promote science process skills and content knowledge, set up data collection stations with calendars, charts, graph paper, tracing paper, plenty of writing and art materials, and a variety of...
measurement tools so children can document their observations of the planting and growth process.

**Tips to take gardening further**

Once the class has the basics down, consider some of these further explorations.

**Seek out natural treasures.** Even in urban areas, children can find many natural objects during neighborhood walks. Take advantage of the natural settings near your school, such as parks or public gardens. Take walks to find and document the first signs of a new season; to search for insects, rocks, and leaves; or to look for birds. Let the children bring their found natural items inside, when possible. A great alternative is for children to take photographs. Try to get as close as possible to capture details, take pictures from multiple angles, and get some shots of the surroundings.

_Nature photos can become the focus of class-made posters, stories, scrapbooks, and other nature-based projects._

Add items from nature walks and from the grocery store to the science and other classroom areas. Include herbs, fruit peels, leaves, sticks and branches, pinecones, tree seed pods, acorns, rocks, and shells. Ask a florist for cuttings and trimmings from flowers or for flowers that are past their prime, so children can take them apart—touching and smelling the petals and stems, and measuring, sorting, and graphing the parts. A construction site may be willing to donate a tree stump or large stones to incorporate in classroom construction and dramatic play activities.

Consider adding live treasures to the science area too! Simple habitats for small garden creatures such as snails, worms, beetles, and crickets let children gain firsthand knowledge and develop appreciation of these animals.

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**Snail Trails and Tadpole Tails: Nature Education for Young Children**, by Richard Cohen and Betty Phillips Tunic, has tips on adding small critters to your classroom.

**Diversify.** Use a variety of seeds for sprouting activities so children can compare and contrast growth rates and discuss concepts like diversity. Bean soup mixes and bird seed mixes are inexpensive ways to get a variety of seeds for sorting and sprouting. Also consider other grocery store “seeds,” such as corn and wheat kernels, sunflower seeds, and lentils. Use the seeds you have on hand, like those from the classroom pumpkin or from a lemon juiced for a cooking project.

Sprout seeds by putting them in a plastic baggie with a damp paper towel and taping it to the window. This quick project will show results in a week or less. Beans are often used for sprouting because they are almost foolproof. They sprout quickly and grow fast, which helps hold the children’s interest; and they produce relatively large leaves, which make the plant easy to observe. Seed sorting and sprouting activities let children use many science process skills (measurement, comparing and contrasting, charting, and so on), and the children can pot all the ones that sprout later in a container in the classroom or a window box outside for continued exploration and enjoyment.

**Focus on the five senses.** Herbs such as sage, oregano, rosemary, and a variety of mints are easy to grow in a sunny place in the classroom and have smells that are both strong and appealing. In addition, children can taste these herbs and use them to season snacks. Strawsflower, hens and chicks, and lamb’s ear are all hardy plants that have interesting textures and can take touching by small hands. Flowers such as marigolds, pansies, and violas do well in small window containers and add eye-catching color to your classroom in the spring. Also, consider dwarf nasturtiums. These plants have bright, cheerful blooms and edible leaves and flowers with a pungent, watercress-like flavor and scent.

For these sensory explorations, it’s best to purchase young plants rather than trying to grow them from seeds. Although fairly easy to care for when mature, most of these plants can be difficult and time-consuming to start from seed.

Note: Take some time to discuss how some natural items and plants are good for people to eat and some are not and can make people very sick. Strongly discourage children from tasting things unless directed to by a teacher. Be sure that any natural objects available for exploration and free play in the classroom are nontoxic.

**Play in the dirt.** Put high-quality potting soil in the classroom sensory table and add child-size gardening hand tools, as well as containers and plastic flower pots of many sizes to fill. Later, add a variety of rocks, high-quality plastic insect models, and a handful of seeds (separately or together) for continued interest. Keep the soil just a little damp to prevent it from becoming dusty.

Extend this play outside by designating an area in the playground where children can dig holes. And the only thing better than just playing in the dirt is to add some water. Mud play allows for the scientific exploration of soil composition, erosion, and evaporation—plus, it is fun!

**Provide realistic representations.** Display pictures and posters of the natural objects children are investigating to offer visual interest and content knowledge resources. Children can use posters and guides to compare and contrast characteristics of similar plants, small garden creatures, or birds. Nonfiction books provide facts about objects’ properties and animals’ life cycles. Choose resources with high-quality artwork and age-appropriate explanations.

Realistic and durable models of small garden creatures or plants allow children to explore the features of natural objects when handling the real thing could cause harm. They are fantastic props for dramatic play. Posters, guides, and models can be found in gift shops of museums, zoos,
and botanic gardens, as well as from teacher stores and Internet distributors.

**Make connections.** Gardening projects are not about science alone. Nonfiction and fiction books about plants, gardening, and nature can link literature and stories with hands-on knowledge. Also explore related social studies concepts like responsibility and care of nature, farmers and their role in the community, and environmental advocacy.

Tie in edible plants you grow and seed explorations with nutrition concepts. Children love making a seed trail mix for snack and discovering what parts of plants they eat every day (broccoli is a flower??). Provide for role-play and movement activities by acting out plant growth and engaging in gardening finger plays and songs. Find nature-based songs and chants online.

Children can combine nature with art by making natural material collages, photographing nature, and drawing or building models. Display natural objects collected by teachers and children on trays and shelves so children can sort and classify them. Have children spend time touching, smelling, sorting, and observing with magnifying glasses.

Allow the natural treasures to travel to other areas of the classroom to be incorporated into dramatic and construction play. Also, use gardening and nature-based play as a fun way to learn meaningful social skills, such as turn taking, cooperation, and responsibility for other living creatures.

**Live and learn.** Talk to local gardeners and invite them to speak to the children about plants and garden critters in your area. Read some basic gardening books and visit related Web sites (some favorites are provided on p. 48). Botanical gardens often have workshops for teachers. Most important, give yourself the time to learn through experience. Don't get discouraged when you or the children make mistakes.

As in the rest of life, you live and learn. Try turning things that don't work into opportunities for discussion and exploration. Remember, the focus is on process rather than product—and sometimes, mistakes can provide better learning experiences than when everything goes right!

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**Conclusion**

As I reviewed my classroom journal, my observations of the children, and all the pictures I had taken, I was amazed at how much we had actually done related to nature and life science over the course of the school year. I knew from the beginning that I wanted to bring nature into our learning experiences, but it wasn't really the main focus of our classroom. We had done so many, many other things. But looking back, I was able to see that throughout the months, natural materials and nature play had been a subtle yet important constant in our classroom.
Remember, the focus is
on process rather than
product—and sometimes, mistakes can
provide better learning experiences than when
everything goes right!

excitement when now natural
materials showed up in the classroom.
It was a year of discovery and learning for me, the
assistant teacher, and for the children. It was a rewarding
exploration and introduction for us all to some of the
natural world we live in.

Gardening and nature-based play curriculum do not
require a teacher to be an expert botanist or biologist.
These activities are all about the elements of science ed-
cation rather than expertise on the part of the children
and the teacher. It is about tapping into everyone’s inner
scientist and encouraging the attitudes, process skills, and
content knowledge that are central to scientific thinking.

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Interested in Exploring More?

Check out these resource books on nature-based education:

Last Child in the Woods: Saving Our Children from
I Love Dirt! 52 Activities to Help You and Your Kids Discov-
Gardening with Children: Brooklyn Botanic Garden
All-Region Guide, by the experts at the Brooklyn Botanic

Ready to get started?

Check out these Web sites for information and ideas

Growing a Green Generation—http://horticulture.unh.edu/
mgg.html
Growing Minds, Farm to School—www.growing-minds.org/
lessons.php
Junior Master Gardener—www.jmgkids.us/index.k2?did=11777
Kid’s Gardening—www.kidsgardening.com/themes/
preschool.asp
The Kid’s Garden UK—www.thekidsgarden.co.uk
My First Garden—http://urbanext.illinois.edu/firstgarden
National Gardening Association—http://assoc.garden.org
Section 13
EARTHWORM INFORMATION

Redworms – *Eisenia fetida, Allolobophora caliginosa*

Nightcrawlers – *Lumbricus terrestris*

**Background.** Earthworms are members of the phylum Annelida, or ringed animals. They are fairly simple life-forms, put together from a number of disk-like segments stuck together like a long flexible roll of coins. Earthworms have no internal skeleton like a fish, no hard protective exoskeleton like an insect, and no shell into which they can withdraw. Worms are flexible, elongated bundles of muscle, uniquely suited for life underground.

The characteristic wriggling of earthworms is accomplished by the contraction of two kinds of muscles. When the short muscles that circle each segment (like lots of rings on a finger) contract, the worm gets thinner and longer. When the long muscles that connect all the segments contract, the head and tail are pulled toward each other, and the worm becomes short and fat. Depending on which end of the worm is anchored, the worm can move along the surface of the ground or through its burrow effectively in either direction, head first or tail first.

Earthworm organs are quite different from ours, making it possible for them to live their very different lifestyle efficiently. Earthworms have five pairs of simple hearts that pump blood throughout the body. They have no lungs. Instead the blood flowing close to the worm’s surface absorbs oxygen and releases carbon dioxide directly through the moist skin (called the cuticle). For this reason earthworms can live for some time in water if the oxygen supply is adequate. They don’t drown per se, but they may suffocate if the oxygen content is low. This is why worms leave the soil and crawl out on the sidewalk during a heavy rain—they are seeking oxygen. Earthworms are not adapted to feed in water, however, so they would starve to death in due course.

Instead of a nose, ears, and eyes, earthworms have a nervous system throughout their bodies that controls actions in response to environmental stimuli, such as vibrations, heat, cold, moisture, light, and the presence of other worms. They have no brain, however, so worms do not ponder their lowly lot in life, nor do they plan a strategy for obtaining their next meal or crossing the sidewalk safely.

**Reproduction.** Like all animals earthworms have effective strategies for begetting their own kind. With earthworms it is not a matter of boy meets girl, but rather a simpler matter of worm meets worm. All worms carry two sets of sexual organs, but they cannot fertilize their own eggs—mating is still a necessary part of reproduction. Mature earthworms have an enlarged band some distance from the head. This enlarged clitellum plays an important role in reproduction.

In mating, two worms approach each other nose to nose. With their bodies touching, they slide past each other until their heads are a bit past the clitellum. Both worms pass sperm through an opening located between the head and the clitellum, into a temporary holding receptacle in the other worm. The two worms separate. The clitellum secretes a liquid that solidifies into a flexible tube. As the tube lengths, the worm backs out of it. Soon the tube covers the front part of the worm. The worm lays a few eggs inside the tube, deposits some of the stored sperm, and withdraws from the tube, leaving the eggs and sperm inside the tube. The ends of the tube pinch off to form a cocoon, and the whole thing shrinks to a tidy package about the size of a fat grain of
rice. The cocoon is left alone sitting on or just under the surface of the soil. The worm continues to produce cocoons until the sperm is used up. Cocoons are durable, can overwinter in cold climates, and can wait out hot dry spells in arid environments. After 3 weeks (ideal conditions) or longer the cocoon opens, and out sallies the next generation.

Earthworms feed on decomposing organic material, mostly vegetation, from the surface of the soil and within the soil itself. In the process of burrowing and feeding they process tons of soil in a typical pasture or garden, improving the quality of soil for plants and other animals.

**Obtaining redworms and night crawlers.** You can often obtain earthworms from local bait stores. You may be able to dig worms from your own garden, or you can order them from Delta Education. Redworms are used for worm composting and are sometimes available at garden supply stores.

**Care of Redworms.** Redworms can be kept in shipping container for short periods. Upon arrival, mist with water to moisten, but do not make soil wet. Worms can be kept in the refrigerator for short periods of time. To maintain worms for a longer period of time, keep at room temperature in diffused light, feeding crushed dead leaves or cornmeal sprinkled over the surface of the soil. Add rich soil (preferably humus) as needed, and remove any mold as it appears.

Worms will eat bits of lettuce, carrots, and other vegetable matter. Oatmeal and decaying leaves are also good food sources.

Use dry leaves that are already decomposing to feed the worms. There are a few types of leaves that you should not use as food for the worms—bay, eucalyptus, and magnolia leaves, and needles from pine, fir, and cedar trees. These types of leaves will kill your worms.

A good temperature for redworms is 15° to 26°C—good room temperatures. (Night crawlers need much cooler temperatures and will do fine in the refrigerator.) Red worms will slow down their activities in colder or hotter temperatures.

**Care of night crawlers.** Keep the night crawlers in the container they came in, or a 1/2 L container about three-quarters full of damp soil. Poke holes in the lid for ventilation. Store the worms in the refrigerator or a cool place for a few days before they are introduced to students.

**Night crawlers** prefer cooler temperatures and deep burrows so will not survive well in the terrarium with red worms over long periods of time. You can maintain night crawlers in a container with some moist, loose soil and food. Unlike red worms, night crawlers are hard to keep alive in the classroom and will soon die and become part of the soil. If you want to keep them alive for a month or so, keep them at a cool temperature by putting them in the warmest part of the refrigerator.

**What to do with the earthworms when the investigations are completed.** Redworms can be maintained in a terrarium, worm bin, or worm jar as long as food (dry leaves, weeds, fruit and vegetable scraps) is provided. The worms can be passed along to another class about to conduct the module, or released in a garden compost pile. Nightcrawlers survive best in the cool temperatures of your refrigerator. When observations are done, nightcrawlers can be released into a flower garden. These earthworms are also used as bait for fishing or as food for reptiles and amphibians.

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Earthworm Observations

Hold the clear cup up to the light and look at your earthworm. What can you see inside its body?

➢ You may see bits of dark soil passing through the worm’s digestive track.
➢ You may also see the dark red blood vessel going down the length of the worm.

Place the earthworm on the paper plate.

➢ Touch it. How does it feel?
➢ Observe the worm as it moves. Describe its movement.
➢ Which end of the worm do you think is the front? Why?
➢ Observe the worm with a hand lens. What do you notice?

Earthworms do not have a nose, eyes, or ears. To gather sensory information about their environment, they “feel” their way through the soil. You will notice that the worm’s body is divided into segments. Some types of worms have over 100 segments. How many does your earthworm have?

➢ How would you describe the color of your worm? How might its color help it to survive?
➢ Locate the thickening or swelling of the worm’s body about one-third of the way down from the front end. This is called the clitellum and is also referred to as the saddle. It is only found on adult worm. The clitellum plays an important role in reproduction. (The clitellum is not noticeable on some types of worms.)
➢ Run your fingers along the underside (ventral side) of the worm. Do you feel small bristles? These are called setae. What do you think the function of the setae is?

Draw a picture of your worm:

Other Investigations:

➢ Place a damp paper towels and a small tunnel made from black construction paper on the plate. Put the worms in the middle of the tray. Predict what you think the worms will do. Observe which materials the worms move toward.
Worm Scenarios

Discuss ideas for how you could handle the following situations. How might you react in the moment? What actions you could take after the incident to promote your desired goals for children’s learning and development?

Children’s ages 3-5

1. As part of a gardening project, you decide to bring worms into the classroom to allow the children to investigate them. You purchase some night crawlers at a bait store. At circle time, as soon as you bring out a live worm to show the children, Casey, a 4 year old, screams and shouts, “I hate worms” and jumps back in apparent fear. Even when you assure Casey that “It’s okay if you don’t want to touch the worm,” the child continues to react fearfully and won’t sit back at their place on the carpet.

2. Your class has been investigating animals that live in soil, such as worms, rolly pollies, and ants. At outside time, you encourage children’s explorations by providing small shovels, trays, magnifying lenses, and clipboards with paper and drawing utensils. This activity is very popular. One morning at drop off time, a parent tells you that she does not want her child to dig in the dirt or to touch worms and bugs. She tells you that it’s dirty, that he should not be touching things that live in the dirt because “he might get sick.”

3. A group of children is at the table with you observing worms and investigating how they move. They are engrossed in the activity and making exciting discoveries. A teacher from another classroom comes into the room. When she sees what the children are doing, she loudly says, “Are those worms? Gross! Don’t put those things near me!”

4. During a worm observation activity, some of the children are not being gentle with the worms. Although you have emphasized that worms are “the Earth’s friends” and modeled how to handle the worms gently, you see that some are handling them as if they are not living things... stretching them out, poking them with the magnifying glass, and constantly moving them around rather than focusing on observation. You are concerned for the worms’ safety.

5. During a project on worms, you decide to make a worm jar with the children so they can observe how worms make tunnels underground. The children help to layer the sand and soil and add 10 worms to the jar. For a couple of weeks, the children observe the worms tunneling, and make drawings of their observations in their science notebooks. After 3 weeks, it is time to let the worms go. The children want to say goodbye to the worms, so you spill out the worm jar and let them hunt for the worms, counting them as they find them. They discover that one of the worms isn’t moving. When you look at the worm, it is obviously dead. When you tell the children this, they are very sad and want to know “Why did it die?”
Ramps and Pathways
Developmentally Appropriate, Intellectually Rigorous, and Fun Physical Science

Betty Zan and Rosemary Geiken

Jackson and Luis, two preschoolers, stand across from one another at a table on which are placed a few ramp segments (one-foot lengths of cove molding), several dry sponges of differing sizes, a few clear containers, and some marbles. Jackson creates an incline by stacking some sponges and placing one end of a segment on top. He places a container at the lower end, releases the marble at the top of the incline, and watches the marble roll down and into the container.

Luis also creates an incline, but he places the high end on the edge of the upright container and the lower end on two sponges, so his marble rolls in another direction. After a few unsuccessful tries to get the marble to roll into the container, Luis picks up the ramp segment and rotates it 180 degrees (so that the end that was lower is now propped on the edge of the container). He places the marble on the track and watches as it still rolls away from the container. Finally, Luis places three more sponges under the low end, raising it higher than the end propped on the container. He tests his incline again, and when the marble rolls into the container, Luis giggles.

We have spent many years providing professional development in the area of science education, working alongside teachers and observing children in the classroom. These experiences have convinced us that activities involving inclined planes are possibly the best science activities we have ever encountered. We call our collection of classroom activities involving inclined planes Ramps and Pathways. These activities engage children in investigations involving force and motion, foster the development of important science inquiry skills, and provide numerous opportunities for integration across curricular domains. And they are great fun!

In this article, we share our enthusiasm and our experiences supporting children in Ramps and Pathways investigations, and we seek to inspire teachers to implement similar activities in their classrooms. The young boys in the opening story are not simply playing with the incline and marble; in each boy's quest to figure out how to get the marble to do what he wants, he is investigating, trying out different ideas, and varying his actions. This is what scientists do. It is called inquiry. And it is one of the primary goals of science education. We hope that our experiences will arouse in teachers the same curiosity and eagerness to learn that we see in children when they encounter these activities.

For several years we have offered early childhood physical science workshops for early childhood teachers across Iowa and across the country. Our experience with Ramps and Pathways began in a university-run laboratory school in Waterloo, Iowa, serving primarily children from minority cultures whose families have low incomes. We also tested the project activities with pre-K through second grade teachers and children in a variety of settings.
One of the beauties of ramp building in the classroom is its simplicity. When we started out using ramps, we simply introduced wooden cove molding and marbles to the block center. Over the years, we have explored variations, some of which we will describe here, but the basic ingredients remain unchanged: cove molding, marbles, and unit blocks. We have used these materials successfully with children of diverse backgrounds and abilities, with typically developing children and children with disabilities, and with English-speaking children and dual language learners. The ramp materials offer interesting challenges for children of all ages and levels of development.

Setting up the classroom

In our work with teachers, we have learned about creating environments that inspire active investigation and invite children to try out their ideas. The following paragraphs describe the materials, space, and time needs for implementing Ramps and Pathways.

Materials

Wood cove molding can be found in most building supply stores. We have had the best luck with molding that is 1¼ inches wide (marbles wobble too much on wider widths). Sections of varying lengths (1-, 2-, 3-, and 4-foot lengths) are best, but if the classroom is small, the 4-foot lengths can be omitted. Most classrooms need at least 18 of each length.

Marbles of different sizes move easily down the cove molding ramps. Variations in size allow children to compare the movement of large and small marbles. Other variations include steel marbles, blocks or other objects that do not roll, and items that roll differently (such as spools, egg-shaped objects, spheres with bumps). Divided organizers, often found in hobby stores, can serve as storage containers for the marbles and other objects.

The best place for the ramps is in the block center. Children use wood unit blocks to build elaborate ramp structures. They also can use large hollow wood blocks, large interlocking blocks, or large cardboard blocks. If ramps are being used on tables, as in the opening vignette, large sponges make great supports. Some teachers cut openings in cardboard boxes that can be used for propping up the ramp sections. However, if all of the blocks are being used, children can use whatever else is available—shelves, chairs, tables, or other items.

Space

Space can be an issue. Once children start building ramps, they want to build them bigger and bigger! For younger children especially, this often means longer ramps. We’ve seen classrooms with ramp sections propped on every chair and desk. Of course, not every classroom has the luxury of dedicating that kind of space, but we’ve found that children can be very creative in using small spaces. Teachers also use hallways, lunchrooms, and open conference rooms, or they take the ramps outdoors.
Time

The National Science Education Standards stress that "building scientific understanding takes time on a daily basis and over the long term" (NRC 1996, 44). An effective learning environment provides ample time for children to engage with materials. Children need time to revisit ideas, reflect on what they have done, and revise their thinking. When we speak of time, we mean time both during the day and time across the days, weeks, months—even years. In the laboratory school where we developed the Ramps and Pathways program activities, the materials were available in the block center every day and in every classroom, preschool through grade 2. Some children worked with ramps for five years, and they never grew tired of them or ran out of ideas.

Big ideas for early childhood physical science

The following six suggestions can guide the implementation of any high-quality physical science curriculum. We offer these "big ideas" in the spirit of sharing with teachers what we have learned over the years about implementing Ramps and Pathways and other physical science activities.

1. Teachers need experiences with classroom materials to understand the possibilities for learning.

It is critical for teachers themselves to investigate the ramp materials before putting them out for children. To be able to support young children’s development of scientific knowledge and reasoning, teachers must have some understanding of how inclined planes work. They need to experiment with the materials and figure out (among other things) how to move a marble without touching it and how to make a marble go up a ramp section or turn a corner. They need to think about their thinking as they investigate the materials. By investing time in exploring the materials, teachers can see the possibilities and be better prepared to facilitate children’s work with the ramps.

An important aspect of the learning in Ramps and Pathways is the connections made between actions and reactions. For example, marbles travel faster if you put four blocks rather than two under the high end of a ramp. This understanding offers the possibility of constructing a relationship between the degree of incline and the speed of the marble. As teachers work further with the materials, they identify many more connections or relationships that children can make.

2. Effective learning environments inspire interests and ideas and allow children to try out their ideas.

According to Benchmarks for Science Literacy (AAAS 1993), children should be actively involved in exploring phenomena that interest them. The importance of interest in young children’s learning cannot be overstated. Piaget ([1954]1981) said interest is the fuel that drives the motor of mental activity, much like gasoline powers an engine. Unlike adults, who can often force themselves to pay attention,
most young children lack the self-regulation to pay attention when they are not interested in something. However, young children do not necessarily have short attention spans. They are highly capable of devoting long periods of attention to something that captures and engages their interest and purpose. We have seen this repeatedly when children engage in activities that support experimentation, as Ramps and Pathways does.

The opening vignette illustrates how young children approach the ramp materials: they try to figure out what they can do with them. They have ideas, and they try out their ideas to see what will happen. For this reason, it is very important to set up a classroom environment in which children feel safe trying their ideas, without fear of failure. Unfortunately, for far too many children, school is not a place where it is safe to actively experiment and try out ideas; they learn, even at a young age, that there are right answers and wrong answers, and that wrong answers are to be avoided. When working with ramps, teachers should refrain from correcting children or giving them right answers. Instead, the teacher’s role is to support continued inquiry by intervening with questions or comments that inspire further experimentation.

3. To accurately understand and assess children’s reasoning, teachers must observe children closely.

Close observation is the only way teachers can learn how children are thinking and design appropriate interventions and variations. However, observation is more than simply watching children. It must be accompanied by knowledge about what is being observed, how the children’s actions demonstrate their thinking, and how the event connects to learning goals and objectives.

If one observes closely, one can see in the story at the beginning of this article several demonstrations of a young child’s competence. First, Luis persists in his own purpose—getting the marble to roll into the container—until he is successful. Second, he tries different strategies—some of them illogical from an adult perspective—before he is successful. And finally, he experiences the satisfaction of solving a problem on his own, without adult intervention. These three elements are included, in one form or another, in early childhood learning standards across the country, often under headings such as “Approaches to Learning,” “Initiative,” or “Problem Solving.”
4. Support children's investigations and conceptual development with interventions that focus on reasoning rather than right answers.

Young children's investigations often lead to common erroneous ideas, or what the science education community refers to as preconceptions. For example, even after seeing a marble roll down an inclined plane and fly off the end, many children will still predict that a marble will drop straight down into a container when it reaches the end of a ramp (demonstrated by placing a container to catch the marble directly under the end of the ramp). Preconceptions are common—often persisting well into adulthood—and are highly resistant to change. Teachers experienced in supporting inquiry know how to encourage experimentation so that children can correct their preconceptions through acting on objects and observing the results of their actions.

5. Sharing experiences and the results of investigations strengthens science learning as well as the development of communication.

In a reassessment of current science instruction, Metz (1995, 117) stresses that "the development of scientific knowledge is, in many aspects, a social activity." Scientists don't work alone; they rely on frequent communication with other researchers. Experimenting and making errors are vital to the process of scientific inquiry. They require an environment in which children are free to collaborate and take risks.

We have seen teachers use many strategies to foster communication between young learners during Ramps and Pathways activities. They encourage children to work in groups and to help each other by sharing ideas. They provide materials so children can draw and write about their ramp structures. Photos of children's ramp structures provide excellent writing prompts and can be used to stimulate discussions. During group time, teachers can invite children to reflect on what they have done in the ramps center.

6. Ramp activities offer multiple opportunities to integrate other curriculum areas.

One of the most valuable aspects of a ramp project is the ease with which it addresses other areas of the curriculum. Mathematics is everywhere; children engage in spatial reasoning as they decide where to position blocks or how to align the ramp sections; they experiment to figure out how to use angles so marbles will turn corners; they count blocks to compare heights and predict how many more blocks they will need—the list of math concepts could go on and on. Literacy possibilities include using digital photos as writing prompts. Teachers tell us that even reluctant writers are eager to write about their ramp structures. Some teachers help ramp makers create class books (one second grade class made an alphabet book of ramps). For social studies, children can consider the importance of ramps in the workplace or to persons with disabilities. An art teacher steeped in the Reggio Emilia approach explained to us how the children's ramp structures integrate art and architecture.

Pathways to success

Teachers tell us powerful stories about using ramps for science learning in their classrooms. One kindergarten teacher had never thought of herself as a 'science person.' But now, through the Ramps and Pathways project, she says, "I have learned that this science approach is completely doable." A preschool teacher, who says she was "scared" to teach science, boasts that now "we are actually doing science every day and have a sci-
ence center going daily.” Another preschool teacher says, “I do a lot more thinking about science and spend more time on science in the room with the children. I have science on the brain.”

Teachers also report that ramp building decreases behavior problems in their classrooms. For example, a first grade teacher says, “At the beginning of the year, I was told that Reggie had behavior issues ... But we found an area that Reggie excels in. I think that Reggie’s ability to build ramps has positively affected his behavior. I don’t have anymore trouble with Reggie’s behavior in class.”

These reports and our own observations confirm what we have witnessed from the beginning of our project:

Ramps and Pathways is one of the best science activities for engaging both young children and their teachers in inquiry learning. And it is great fun!

References


Young Children Cluster Topics for 2011

We are pleased to announce the following cluster topics for 2011. The Notes column provides suggested content and other information. Please refer to the Manuscript Guidelines on the NAEYC Web site at www.naeyc.org/publications/forauthors/writetopic to read about the due dates and submission process for cluster proposals and articles.

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Section 14
block play: it's not just for boys anymore

Strategies for encouraging girls’ block play

by Barb Tokarz

It is center time in the four-year-old class. Groups of boys and girls are busily engaged in play in the dramatic play, the art center, the library, discovery center, and with table games. The teacher notes that since she has changed the dramatic play area to an ice cream parlor, boys as well as girls are enjoying creating and serving ‘frozen treats’ for their friends. However, an area of ongoing concern is that the block center has only boys playing in it once again. Two girls stand on the perimeter, looking at the skyscraper that the boys are building and appearing as if they would like to join in. However, the boys are using most of the blocks and are so involved in their building that they don’t acknowledge the girls, so the girls move on to the art center where they begin painting at the easels.

As teachers of young children, most of us have seen this situation, with some variation, played out in our classrooms.

The absence of girls in the block center concerns early childhood educators because block play provides valuable opportunities for expanding language, social, cognitive, and motor skills. Lucy Sprague Mitchell (as cited in Hirsch, 1996) best describes the importance of block play in saying, “Blocks have been found to be the most useful tool for self-education that young children can play or work with.” This information makes us question how block play became primarily a boys’ activity. What steps can we take as teachers to encourage girls to become involved in block play?

Choosing play activities

When it comes to choosing the block center for play, the decision seems to be based to a large extent on gender and what toys are considered appropriate for boys and girls. This attitude is based primarily on society’s gender expectations. Although there have been great strides made towards equality in recent years, gender stereotypes die hard. Louise Derman-Sparks (1993) believes that although a child’s gender is determined at conception, society has a significant impact in ascribing gender roles to children. This process begins during pregnancy, as traits are ascribed to the unborn child based upon cultural perceptions. Babies who are more active and kick frequently in the womb are thought to be boys; a quieter child is thought to be a girl. After birth, parents decorate and choose clothing for the child based on gender expectations.

Children are socialized into what is considered to be gender appropriate behavior: the toys, activities, and playmates that are appropriate for each gender.

- Boys, who in our culture are perceived to be more active and assertive, gravitate toward activities that are deemed to be more appropriate for them, such as woodworking, blocks, and active outdoor play.
- Girls frequently gravitate toward traditional female activities, such as housekeeping, puzzles, drawing, and books.
- Even when girls are interested in joining in block building and outdoor activities, they are often discouraged by boys through their words and actions (Dodge, Colker, & Heroman, 2002).
- In addition, girls see few women in the building and construction trades.
which reinforces their belief that these are boys’ activities.

Research tells us that by age 4, children are strongly influenced by their perception of society’s expectations, often establishing firm boundaries around gender roles and segregating their play groups around gender (Teaching Tolerance Project, 1997).

**Styles of block play: Is there a difference between genders?**

There are variations in the interaction and play styles between boys and girls that will help teachers understand their behavior in the block center and will encourage increased participation by girls.

- Anderson (1998) characterizes the play behavior of girls by the use of enabling styles of conversation which tend to acknowledge, express agreement, and support what their partner is doing.

- Boys, however, are more oriented to the issues of competition and are focused on getting more than their share of the resources, using their speech as a way to get play partners to withdraw.

Sluss and Stremmek (2004) observed in their study of peer collaboration in the block center that girls were supported by not only the play level of their peers but by the level of social interaction. Girls engaged in almost double the number of assisting behaviors during play (making statements such as “if we need more, we can get them”) in comparison to boys. As a result, they were able to scaffold the play behavior of a less experienced peer and their play became more collaborative as a result. When girls entered a play situation (Sluss & Stremmek, 2004) with girls they did not know, they spent a few minutes interacting socially as opposed to boys, who engaged in play immediately.

Based upon research and observations of girls in block play, girls use blocks as a way to represent and extend their role in the world. In Rejskind’s (1988) discussion of Block’s Theory of Gender Specialization, he describes Block’s view of girls as creative assimilators of information who are oriented to their social structures, strive for continuity, and support accepted values. As girls play with blocks, they engage in many of the behaviors that they have been socialized into: supporting, affirming, giving assistance; and, as a result, they develop strong interpersonal skills. Many of the structures that girls build — such as houses, stores, offices, and churches — are associated with the familiar world that they are a part of and whose structure they support.

Boys on the other hand are seen by Block as being creative accommodators who create new schemes and who are curious and ready to explore. When boys play with blocks, they are focused on the task of building and tend to be unaffected by the communication of another peer. Sluss and Stremmek (2004) have noted that boys often play with their own materials in isolation because they are so focused on their work. Much of boys’ block play is focused on creating more elaborate structures and finding innovative uses for materials.

**The many benefits of block play**

Blocks are a valuable learning tool that grow with children. As children use blocks to construct and represent their experiences in daily living, they grow across all developmental domains.

**Social-Emotional:**

Block play encourages children to make friends, share, take turns, and cooperate.

Children learn to take the perspective of others as they exchange ideas about how to build a structure. Children learn to care for materials and follow safety rules.

**Physical:**

- Children’s small muscles develop as they place blocks to make intricate structures.

- Children gain strength in large muscles as they lift, carry, and stack blocks.

- Children increase eye-hand coordination as they reach for and carefully place a block in a structure exactly where they want it.

**Language Development:**

- Children increase their vocabularies as they have conversations about their structures, and they learn new words to describe sizes, shapes, and positions.

- Children develop writing skills as they create signs for their buildings.

**Cognitive Skills:**

- Block building increases the opportunities for children to problem solve and develop understandings that lead to logical thinking.

- Block building helps children strengthen symbolization and representation skills that are the basis for using and understanding the symbol systems of language and math.

- Children develop skills across a wide variety of content areas, for example:

  - Children develop math skills as they learn about sizes, shapes, order, patterns, weight, length, and fractions.
As children work with blocks, they learn the science concepts of balance and gravity.

As children create structures that resemble the world around them, they increase their understanding of social studies.

Ways to include girls in block play

Since many girls avoid the block area, teachers have to make a special effort to include them. Many girls lack experience with blocks and may not know how to get started. In addition, they may be functioning at an earlier developmental stage in block building than boys of the same age (Dodge et al., 2002). By following these suggestions teachers will find that girls who are hesitant to join in activities with blocks may overcome their initial reluctance and become actively engaged.

Communicate the message that all children may play in all of the learning centers in your classroom.

Locate the block corner next to dramatic play. Children who are going shopping, to school, or to the doctors may come into the block center to build a car to travel in, or to build a structure that becomes the store or school. Allow children to borrow materials from dramatic play to bring into the block corner to support and enrich their play. Choose a time when the block center is not crowded and invite some girls to come in and play with you. Sit on the floor with them and begin building, asking open-ended questions, and supporting them in problem solving if the need arises. Dodge (2002) has indicated that girls feel more comfortable playing with blocks if the center has props to support and extend their play and allow them to represent their understanding of their world.

Some programs have instituted a ‘Girls Only’ block time where girls are coached in ways to use blocks to help develop block-building skills. When girls have mastered block-building skills, then they are encouraged to work in co-ed teams of three or four. In a literature review, Varma also encourages a separate area if possible in addition to the already existing block area where girls will not feel overpowered by boys.

Display pictures of people in non-traditional occupations to counteract gender stereotypes: girls as construction workers and builders and boys as nurses, librarians, and caregivers.

Select literature that supports the idea of women in building and construction. Mothers Can Do Anything by Joe Lasker is a good resource.

Add play props that appeal to girls such as plastic dollhouse furniture, multicultural figurines, and plastic animals. Include colored markers and paper so children can make signs and decorate their structures.

While block play is essential for both boys’ and girls’ social, cognitive, language, and motor development, girls do not engage in block play as frequently as boys. This situation can be attributed to the socialization process — children learn societal expectations for behavior and materials for both boys and girls — lack of experience for girls with blocks, and attitudes of peers that cause girls to feel unwelcome in the block center. There are important differences in the way boys and girls play with blocks; girls use blocks to create an extension of their place in the world whereas boys are often more intent on the creation of structures and the innovative use of materials. Teachers need to be supportive and encouraging of girls to increase participation in the block center and to use diverse strategies to insure that girls gain the important skills that are associated with block play.

References


Children's books


Klein, Norma. (1997). *Girls Can be Anything*. New York: E. P. Dutton and Company. (Ages 5-8.) Marina, along with help from her parents, shows her friend Adam that girls as well as boys can do a variety of jobs.

Section 15
Promoting Creativity for Life Using Open-Ended Materials

Walter F. Drew and Baji Rankin

Creative art is so many things! It is flower drawings and wire flower sculptures in clay pots created by kindergartners after visiting a flower show. It is a spontaneous leap for joy that shows up in a series of tempera paintings, pencil drawings of tadpoles turning into frogs, 3-D skyscrapers built from cardboard boxes or wooden blocks. It can be the movement and dance our bodies portray, the rhythmic sound of pie-pan cymbals and paper towel tube trumpets played by four-year-olds in their marching parade, the construction of spaceships and birthday cakes.

What is most important in the creative arts is that teachers, families, and children draw upon their inner resources, making possible direct and clear expression. The goal of engaging in the creative arts is to communicate, think, and feel. The goal is to express thought and feeling through movement, and to express visual perception and representation through the process of play and creative art making. These forms of creative expression are important ways that children and adults express themselves, learn, and grow (Vygotsky [1930–35] 1978a, 1978b; Klugman & Smilansky 1990; Jones & Reynolds 1992; Reynolds & Jones 1997; McNeill 1998; Chalufour, Drew, & Waitz-Stuplansky 2004; Zigler, Singer, & Bishop-Josef 2004).

This article is based on field research, observations, and interviews about the use of creative, open-ended materials in

Walter F. Drew, EdD, is a nationally known early childhood consultant whose inspiring workshops feature hands-on creative play with open-ended reusable resources. As founder of the Reusable Resource Association and the Institute for Self-Active Education, he has pioneered the development of Reusable Resource Centers as community-building initiatives to provide creative materials for early childhood programs. He is an early childhood adjunct faculty member at Brevard Community College in Melbourne, Florida, and creator of Dr. Drew's Discovery Blocks.

Baji Rankin, EdD, is executive director of NMAEYC, lead agency for T.E.A.C.H. Early Childhood New Mexico. Baji studies the Reggio Emilia approach and is committed to building early childhood programs with well-educated and -compensated teachers who find renewal through promoting children's creativity.
early childhood classrooms and how their use affects the teaching/learning process. We identify seven key principles for using open-ended materials in early childhood classrooms, and we wrap educators’ stories, experiences, and ideas around these principles. Included are specific suggestions for practice.

**PRINCIPLE 1.**

*Children’s spontaneous, creative self-expression increases their sense of competence and well-being now and into adulthood.*

At the heart of creative art making is a playful attitude, a willingness to suspend everyday rules of cause and effect. Play is a state of mind that brings into being unexpected, unlearned forms freely expressed, generating associations, representing a unique sense of order and harmony, and producing a sense of well-being.

Play and art making engender an act of courage equivalent in some ways to an act of faith, a belief in possibilities. Such an act requires and builds resilience, immediacy, presence, and the ability to focus and act with intention even while the outcome may remain unknown. Acting in the face of uncertainty and ambiguity is possible because pursuing the goal is worthwhile. These actions produce a greater sense of competence in children, who then grow up to be more capable adults (Klugman & Smilansky 1990; Reynolds & Jones 1997; McNiff 1998; Zigler, Singer, & Bishop-Josef 2004).

Children and adults who are skilled at play and art making have more “power influence, and capacity to create meaningful lives for themselves” (Jones 1999). Those skilled at play have more ability to realize alternative possibilities and assign meaning to experiences; those less skilled in finding order when faced with ambiguity get stuck in defending things the way they are (Jones 1999).

In Reggio Emilia, Italy, the municipal schools for young children emphasize accepting uncertainty as a regular part of education and creativity. Loris Malaguzzi, founder of the Reggio schools, points out that creativity seems to emerge from multiple experiences, coupled with a well-supported development of personal resources, including a sense of freedom to venture beyond the known. (1988, 68)

Many children become adults who feel inept, untalented, frustrated, and in other ways unsuited to making art and expressing themselves with the full power of their innate creative potential. This is unfortunate when we know that high-quality early childhood experiences can promote children’s development and learning (Schweinhart, Barnes, & Weikart 1993).
The Association for Childhood Education International (ACEI) has enriched and expanded the definition of creativity. Its 2003 position statement on creative thought clarifies that "we need to do more than prepare children to become cogs in the machinery of commerce":

The international community needs resourceful, imaginative, inventive, and ethical problem solvers who will make a significant contribution, not only to the Information Age in which we currently live, but beyond to ages that we can barely envision. (Jacinto 2003, 218)

Eleanor Duckworth, author of *The Having of Wonderful Ideas* (1996), questions what kinds of people we as a society want to have growing up around us. She examines the connection between what happens to children when they are young and the adults they become. While some may want people who do not ask questions but rather follow commands without thinking, Duckworth emphasizes that many others want people who are confident in what they do, who do not just follow what they are told, who see potential and possibility, and who view things from different perspectives. The way to have adults who think and act on their own is to provide them with opportunities to act in these ways when they are young. Given situations with interesting activities and materials, children will come up with their own ideas. The more they grow, the more ideas they’ll come up with, and the more sense they’ll have of their own way of doing things (E. Duckworth, pers. comm.).

**Principle 2**

Children extend and deepen their understandings through multiple, hands-on experiences with diverse materials.

This principle, familiar to many early childhood educators, is confirmed and supported by brain research that documents the importance of the early years, when the brain is rapidly developing (Jensen 1998; Elliot 2000). Rich, stimulating experiences provided in a safe, responsive environment create the best conditions for optimal brain development. The years from birth to five present us with a window of opportunity to help children develop the complex wiring of the brain. After that time, a pruning process begins, leaving the child with a brain foundation that is uniquely his or hers for life. The key to intelligence is the recognition and creation of patterns and relationships in the early years (Gardner 1983; Jensen 2000; Shonkoff & Phillips 2000; Zigler, Singer, & Bishop-Josef 2004).

The importance of active, hands-on experiences comes through in the stories that follow, related by several early childhood educators.

At the Wolfson Campus Child Development Center in Miami, program director Patricia Clark DeLaRosa describes how four year old preschool children develop some early understandings of biology and nature watching tadpoles turn into frogs. The fact that this change happens right before their eyes is key to their learning. The children make simple pencil drawings of the characteristics and changes they observe.

One day during outdoor play, the teachers in another class see that children are picking flowers from the shaded area and burying them. This leads to a discussion with the children about how to prepare a garden in which to grow flowers and vegetables. Children and teachers work together to clear weeds and plant seeds. They care for the garden and watch for signs of growth. Over time they observe the plants sprouting, leaves opening, and colorful flowers blooming. The direct, hands-on experience inspires the children to look carefully and to draw and paint what they see.

Another group of children in the same class takes walks around downtown Miami. The children then talk about what they saw, build models, look at books, and explore their new understandings in the block play area. DeLaRosa describes a classroom that includes a number of children who display challenging behaviors. Some of the architectural drawings the children produce during a project on architecture amaze her. They demonstrate that with a concrete project in which children are deeply interested, and with teachers who guide them and prompt them with stimulating materials and related books, children’s accomplishments can far exceed expectations. Because the children have direct and compelling experiences and multiple ways to express their thoughts, curiosity, and questions, the teachers are able to help them focus and produce, expressing their thoughts and feelings in a positive way.

When an architect supplies actual building plans of a house, the children become even more active. They make room drawings and maps of the house, all the while conversing and building vocabulary. They roll up the plans in paper tubes and carry them around like architects. Because the children are deeply involved in the project, DeLaRosa reports, they experience significant growth in critical thinking and creative problem solving. With questions like "How can we build it so it stands up?" and "Where's the foundation?" they show a growing understanding of the structure of buildings and a deep engagement in the learning process.

Rich, stimulating experiences provided in a safe, responsive environment create the best conditions for optimal brain development.
Claire Gonzales, a teacher of four- and five-year-olds in Albuquerque, points out how open-ended materials allow children choices and independence, both crucial in stimulating genuine creativity. Children make things without preconceived ideas. When teachers support authentic expression, there is no one right or wrong way—there is space to create.

Gonzales describes a child who is fascinated by a stingray he sees on a visit to an aquarium. He is inspired to make a detailed, representational drawing of the stingray that goes beyond anything he has done before. Gonzales relates how he was able to use his memory and cognition to revisit the aquarium because the stingray made such a deep impression on him. The child recalled the connection he made with the stingray and represented the creature’s details—the eyes, the stinger, the gills.

Key to this kind of work by children is the teacher’s respect for both the child and the materials and the availability of open-ended materials like clay, paint, and tools for drawing and writing. Materials can be reusable resources—quality, unwanted, manufacturing business by-products, otherwise destined for the landfill, which can serve as much-needed, open-ended resources: cloth remnants, foam, wire, leather, rubber, and wood. (See “A Word about Reusable Resources.”) Open-ended materials are particularly effective because they have no predetermined use (Drew, Ohlsen, & Pichiari 2000).

Margie Cooper, in Atlanta, Georgia, works with Project Infinity, a group of educators inspired by the schools of Reggio Emilia. She speaks of the value of seeing art making not as a separate area of the curriculum but rather as an extension of thinking and communication. Art making can be especially valuable for young children whose verbal skills are not well developed because the diverse materials offer a variety of ways to communicate. We can learn a lot from children who show a natural affinity for materials, gravitating to them without fear or intimidation. Cooper notes that adults often approach materials, familiar or unfamiliar, with apprehension. Learning from children’s openness to materials is important so as not to teach children their fears or discomforts we as adults may have.

Principle 3
Children’s play with peers supports learning and a growing sense of competence.

Duckworth underscores the importance of this principle, emphasizing that by working and playing together in groups, children learn to appreciate not only their own ideas and ways of doing things, but also each other’s. A child can learn that others have interesting methods and ideas that are worth paying attention to and that can contribute to his or her interests as well.

In a kindergarten classroom in Worcester, Massachusetts, five- and six-year-old children study flowers together before a visit to a flower show. The children see and discuss with each other pictures of flowers
By working and playing together in groups, children learn to appreciate not only their own ideas and ways of doing things, but also each other's.

Painted by Vincent Van Gogh, Claude Monet, and Georgia O’Keeffe. They use some of these pictures as inspiration for their own sketches and paintings. They explore flowers with different colors, paints, paper, brushes, and print making.

To give the field trip a focus, the teacher, Sue Zack, organizes a scavenger hunt. At the flower show, the children work in small groups, searching for wolves, sunflowers, tulips, a large fountain, waterfalls, goats, a yellow arrangement of flowers, and a Monet painting.

At school the children make flower creations using recycled materials. At first, they have difficulty making their top-heavy flowers stand up. Then one child discovers that he can use the recycled wire available on the table to hold the flower upright. Others encountering the problem use their classmate’s solution.

When children discover how difficult it is to make flowers from clay, one child suggests, “We can use the clay to make a vase and put flowers in it instead.” So the project turns into making clay pots. Zack describes the children as being so involved that they seem unaware of her presence nearby. They are engrossed in their flower pots, expressing their thoughts to each other while working and using adjectives such as smooth, bigger, huge, longer, taller, bumpy, dusty, sticky, and cold. All the children are proud of their work, eager to show and share with one another. “Did you make yours yet?” “Where did you put yours?” “What flowers do you have on yours?” “I have a dandelion and tulips.” “My flowers go right from a side to the bottom.”

Here are children excited to be working in small groups and deeply connected to a sense of themselves. They do not look for external motivation or recognition. Rather, they express something direct and clear from within themselves as individuals. This is a wonderful example of endogenous expression, where children draw on their inner resources and express themselves from within.

Learning in a social setting is extended when children use diverse materials and symbol systems such as drawing, building, talking, making, or writing. The interaction among these various symbol systems—that is, different languages children use to express themselves—promotes and extends thinking in individuals and within the group.

Promoting interaction among these expressive languages fosters children’s development and learning. And the languages encompass a variety of subjects, which leads to the next principle.

**Principle 4**

Children can learn literacy, science, and mathematics joyfully through active play with diverse, open-ended materials.

When children play with open-ended materials, Duckworth says, they explore the look and feel of the materials. They develop a sense of aesthetics by investigating what is beautiful and pleasing about the material. The wide variety of forms of different kinds of materials, along with suggestions of things to do and to look at, flow over into artistic and scientific creation. These experiences naturally lead to conversations among children that they can write or draw about or make into books or other literacy or science experiences. Play helps children develop a meaningful understanding of subject matter (Kamil, 1982; Christie, 1991; Stupiansky, 1992; Althouse, 1994; Owocki, 1999; Jensen, 2001; VanHoorn et al., 2002).

The more children use open-ended materials, the more they make them aesthetically pleasing by fiddling, sorting, and ordering, and the more they see the potential in the materials and in themselves. “Knowing your materials is the absolute basis for both science and art. You have to use your hands and your eyes and your whole body to make judgments and see potential,” states Duckworth.

Cathy Weissman Topal, coauthor with Lella Gandini of Beautiful Stuff (1999), points out that children develop power when they build individual relationships with materials. When children have the chance to notice, collect, and sort materials, and when teachers respond to their ideas, the children become artists, designers, and engineers. When children are simply given materials to use without the chance to explore and understand them, the materials do not become part of the their world. Weissman Topal relates,

When a child says, “Oh, I need some of that red netting from onions,” he demonstrates that he has experience, knowledge, and a relationship with the material, a connection. It is not somebody else’s discovery; it is the child’s. Whenever a child makes the discovery, it’s exciting, it’s fun. The child is the researcher and the inventor; this builds confidence. (Weissman Topal, pers. comm.)

Children’s explorations come with stories, histories, associations, and questions. From the questions come the next activities, investigations, and discoveries. A natural consequence is descriptive language; children
naturally want to talk about—and maybe draw about—their discoveries. "Not many things can top an exciting discovery!" says Weisman Topal. Organizing and dealing with materials is a whole-learning adventure. Working in these modes, the child produces and learns mathematical patterns and rhythms, building and combining shapes and creating new forms.

Teachers can promote language, literature, mathematics, and science through creative exploration. Margie Cooper points out that skill-based learning and standardized testing by themselves do not measure three qualities highly valued in our society—courage, tenacity, and a strong will. Yet these three characteristics may have more to do with success in life than the number of skills a person may have mastered.

**Principle 5**

**Children learn best in open-ended explorations when teachers help them make connections.**

Working to strengthen a child's mind and neural network and helping the child develop an awareness of patterns and relationships are the teacher's job. Constructive, self-active, sensory play and art making help both children and adults make connections between the patterns and relationships they create and previous knowledge and experience. The brain, a pattern-seeking tool, constructs, organizes, and synthesizes new knowledge.

Teachers integrate playful, creative art making with more formal learning opportunities such as discussion, reading, writing, and storytelling. They ask questions and listen to the children so that the more formal learning activities are connected closely to the children's ideas and thinking. Teachers provide concrete experiences first: investigating, manipulating, constructing and reconstructing, painting, movement, and the drama of self-activity. Then the reflection and extension involving literacy, science, and mathematics that follow are meaningful. Zack in Massachusetts gives us a good example of this when she organizes a scavenger hunt at the flower show, encouraging children to make connections between their interests and activities at the show.

**When children have the chance to notice, collect, and sort materials, and when teachers respond to their ideas, the children become artists, designers, and engineers.**

**Principle 6**

**Teachers are nourished by observing children's joy and learning.**

A central tenet in the schools of Reggio Emilia is the idea that teachers are nourished by children's joy and intelligence. DeLaRosa clearly demonstrates this tenet as she describes teachers working with children on the architectural plans:

Watching the teachers guide, interact, and work with the children makes me feel extremely excited—joyful just to see the gleam in their eyes. You know the children are thinking, you see them creating and producing and playing with purpose. I am proud to see teachers taking learning to higher levels, not sitting back fester about this problem or that. They could hang on to the fact that they have a hard time with some of the children . . . but they don't. They look at the positive and move on. (Pers. comm.)

Teachers and children learn together in a reciprocal process. The exciting work of the children inspires the teachers to go forward. Children are looking for more and the teachers think, "What else can I do to bring learning to the next level?" "How can we entice them to go further?" "What new materials can I introduce?" and "I can see how to do this!" At times the teachers start up and move ahead of the children, and at times the children move ahead of the teachers. When teachers see what children can accomplish, they gain a greater appreciation for them and for the creative arts and materials.

In addition, the work that children do, while inspired by experiences teachers and parents provide, is at the same time an inspiration to all adults who notice. Sue Zack notes,

The flower unit forced me to make the time to listen, reflect, and write down observations of the children. It felt good! It is what I need and what the class needs in order to be a group that communicates, experiences life, creates, learns, and cares about each other. (Pers. comm.)

**Principle 7**

**Ongoing self-reflection among teachers in community is needed to support these practices.**

It is vital for teachers to work and plan together to promote children's creativity and thinking. By meeting together regularly over a few years, teachers connected with Project Infinity in Atlanta have developed the trust to have honest conversations with each other regarding observations of children and classroom experience—not an easy task. They are doing research and constructing knowledge together about how children build relationships (M. Cooper, pers. comm.). Just as children learn and grow in community, so do their teachers (Fosnot 1989).
Conclusion

Play and the creative arts in early childhood programs are essential ways children communicate, think, feel, and express themselves. Art making, fiddling around with bits of wood and fabric or pieces of plastic and leather, reveals the gentle spirit creating simple forms and arrangements, touching the hands, hearts, and minds of young children—and adults.

Children will succeed when they have access to a wide variety of art-making materials such as reusable resources, and when they are surrounded by adults who see and believe in the creative competence of all children and are committed to their success in expressing themselves. As we trust the process, as we encourage and observe the emerging self-initiative and choice making of the children, we come to more fully understand the intimate connection between the spirit of play and the art-making process.

Given these optimum circumstances, children surprise and delight us—they create structures and thoughts no one has seen or heard before. We adults develop a greater appreciation for the children and for the power of creative art making and materials, thus providing a strong motivation for adults to continue teaching and children to continue learning in this way.

In this era of performance standards and skill-based/outcome-based education, it is more important than ever for educators and families to articulate the values and support the creativity of play and exploration as ways to meet the standards—and to go beyond them.

References


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Section 16
The Little Boy
By Helen E. Buckley

Once a little boy went to school.
He was quite a little boy.
And it was quite a big school.
But when the little boy
Found that he could go to his room
By walking right in from the door outside,
He was happy.
And the school did not seem
Quite so big any more.

The little boy looked at the teacher's flower.
Then he looked at his own flower,
He liked his flower better than the teacher's.
But he did not say this,
He just turned his paper over
And made a flower like the teacher's.
It was red, with a green stem.

One morning,
When the little boy had been in school a while,
The teacher said:
"Today we are going to make a picture."
"Good!" thought the little boy.
He liked to make pictures.
He could make all kinds:
Lions and tigers,
Chickens and cows,
Trains and boats -
And he took out his box of crayons
And began to draw.

On another day,
When the little boy had opened
The door from the outside all by himself,
The teacher said,
"Today we are going to make something with clay."
"Good!" thought the boy.
He liked clay.
He could make all kinds of things with clay:
Snakes and snowmen,
Elephants and mice,
Cars and trucks -
And he began to pull and pinch
His ball of clay.

But the teacher said,
"Wait! It is not time to begin!"
And she waited until everyone looked ready.
"Now," said the teacher,
"We are going to make flowers."
"Good!" thought the little boy,
He liked to make flowers,
And he began to make beautiful ones
With his pink and orange and blue crayons.
But the teacher said,
"Wait! And I will show you how."
And she drew a flower on the blackboard.
It was red, with a green stem.
"There," said the teacher.
"Now you may begin."

The little boy looked at the teacher's dish
Then he looked at his own.
He liked his dishes better than the teacher's
But he did not say this,
He just rolled his clay into a big ball again,
And made a dish like the teacher's.
It was a deep dish.
And pretty soon
The little boy learned to wait
And to watch,
And to make things just like the teacher.
And pretty soon
He didn't make things of his own
anymore.

Then it happened
That the little boy and his family
Moved to another house,
In another city,
And the little boy
Had to go to another school.
This school was even bigger
Than the other one,
And there was no door from the outside
Into his room.
He had to go up some big steps,
And walk down a long hall
To get to his room.
And the very first day
He was there, the teacher said,
"Today we are going to make a picture."

"Good!" thought the little boy,
And he waited for the teacher
To tell him what to do
But the teacher didn't say anything.
She just walked around the room.

When she came to the little boy,
She said, "Don't you want to make a picture?"
"Yes," said the little boy.
"What are we going to make?"
"I don't know until you make it," said the teacher.
"How shall I make it?" asked the little boy.
"Why, any way you like," said the teacher.
"And any color?" asked the little boy.
"Any color," said the teacher,
"If everyone made the same picture,
And used the same colors,
How would I know who made what,
"And which was which?"
"I don't know," said the little boy.
And he began to draw a flower.
It was red, with a green stem.
What Kind of Mindset Do You Have?

**Growth Mindset**
I can learn anything I want to.
When I'm frustrated, I persevere.
I want to challenge myself.
When I fail, I learn.
Tell me I try hard.
If you succeed, I'm inspired.
My effort and attitude determine everything.

**Fixed Mindset**
I'm either good at it, or I'm not.
When I'm frustrated, I give up.
I don't like to be challenged.
When I fail, I'm no good.
Tell me I'm smart.
If you succeed, I feel threatened.
My abilities determine everything.

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TRYING NEW IDEAS LEADS TO BETTER SOLUTIONS

Creativity is the special ingredient that often turns building projects into inventions. Just about everything you encounter from toys and tools to gadgets and games is an invention that someone first thought of and then built. But a creative idea can only become an invention when someone figures out how to build it. Proving that an idea really works is one of the requirements for patenting an invention, along with showing it is something no one has ever done before and that it serves some useful function.

For our purposes, however, these requirements can be eased a bit. Any construction that demonstrates a creative solution previously unknown to you, the builder, can be considered an invention. In that spirit, nearly every construction, every model, and every experiment has an element of the invention process. Something new is tried, and something new is learned from the results. The experiments that work are repeated and added to your growing vocabulary of building techniques. In some ways, every time you build something, you are acting like an inventor. But to really develop your skills and spirit for building inventions first requires an understanding of how inventors think.

Learn to Think Like an Inventor

Most inventors have a passion for messing around with materials, building contraptions, conducting experiments, observing how things work, figuring out better ways to solve problems, being inspired by clues others don't see, and then force fitting their good ideas into usable solutions. To help figure out how to make an invention idea work, the inventor must develop a special creative attitude for looking at everyday things from different perspectives. Nearly anything can be considered a possible clue in the mental hunt for the right combination of ingredients to make an invention idea work. For example, suppose the invention problem was building something to catch houseflies. What clues might the inventor get from considering the attributes of duct tape, a piece of cheese, plastic wrap, paper cups, molasses, or ice cubes? How about a combination of these items like a cup and molasses, or cheese and duct tape? A look around the room or a walk around the block will usually reveal all kinds of clues for ways to make any idea work.

Once the inventor has a solution in mind, the process of building an invention is neither to build randomly nor to build according to a plan. Instead, the inventor's work is to build and test, rebuild to improve and test again, and keep on rebuilding until the invention works. Older builders are often able to make sophisticated models of invention ideas with parts that really work, and it's okay for young
builders to make simpler and sometimes nonworking models that come with explanations of how the inventions are supposed to work. This is also the invention process at work. Builders must understand that unsatisfactory results should not be seen as failures, but rather as necessary experiments on the way to solving the invention. Therefore, inventions in progress should be built more for testing functionality than for final appearance. Once you figure out how to make it work, the design can be refined.

A normal part of inventing is getting stuck and then finding ways to get unstuck. One of the best ways to get new input for solving an invention problem is for the inventor to present the work-in-progress to others—but do it this way. Begin the presentation by stating what the invention is supposed to do, and then show what has been accomplished so far. This will at least give credit to the inventor for solving part of the problem. Next comes the explanation of what doesn’t work or where the process has stalled. At this point, you can always count on the others present to spontaneously offer a flood of suggestions for what to do next. The inventor can then decide if any new ideas are worth trying.

HOW TO GET INSPIRATIONS FOR INVENTION IDEAS

Not all inventors work the same way or the same way all the time. Sometimes the inspiration for an invention comes from a personal need or the awareness of a need that others have. Fifteen-year-old Chester Greenwood invented earmuffs in response to other kids laughing when he wore his grandmother’s scarf to the ice-skating pond. And a teenage Levi Strauss is credited with putting rivets at the corners of pants pockets so they wouldn’t rip when gold miners stuffed their pockets with nuggets.

These are good examples of the common expression “Necessity is the mother of invention.” And these types of planned inventions require a clear understanding of what needs to be accomplished. The more the problem is discussed, the more ideas for solutions will be generated, and the closer the inventor will get to finding the best one. In other words, a problem that is well-defined will directly lead the inventor to the best solution.

But sometimes necessity is not the inspiration for invention. Many inventors are inspired by the discovery of some interesting phenomenon. They then use creative thinking to see how that phenomenon might solve some other problem. The inventor of Velcro was inspired by the way barbed burrs from bushes would stick to his pant legs when he walked through the woods. A very young George Ferris’s fantasy of taking a ride on a huge waterwheel later led to his
invention of the Ferris wheel. And after seeing empty pie-baking tins being used in a backyard game, somebody invented the Frisbee.

Discovering a phenomenon by seeing things from a new perspective is what inspires inventions and is one of the most useful skills an inventor can learn. For example, an inventor might look at a paper drinking cup and begin to imagine other things it might be used for. In the mind of the inventor, this is simply figuring out "What else does it want to be?" In some ways, it's like conducting an interview of the object, asking questions that begin with who, what, when, where, why, and how.

An inventor will first play with the cup to discover all its attributes. In its present use, we already know the cup is waterproof, has a certain shape and size, and holds a certain volume. But what if you bend, tear, or cut the cup in some way? How does that change its attributes? What if you use several cups attached together side to side or end to end? And what if you add another material like paper clips, toilet paper tubes, or aluminum foil? By messing around with all the attributes of a paper cup and asking a lot of "What if?" questions, the inventor will learn what else that paper cup wants to be—and even more clearly what it doesn't.

Considering each of these attributes, the inventor will then figure out all the other things the cup might be used for. Because the cup is waterproof to hold liquids, what else could it hold that needs a waterproof container? Maybe fill a cup with soil and use it to start seedlings. The cup may be designed to hold things, but what if it is turned upside-down? Maybe it then becomes a protector of some kind, a translucent shell over small delicate seedlings planted in a garden, or a bare-toes cover for walking on a hot beach. If one of these ideas or some other application is exciting enough to inspire the inventor, it might be further developed into a new invention.

Playing with a material or an object to discover new perspectives and learn what else it wants to be is a technique that can also be used to find creative solutions to well-defined problems. Let's say you want to invent and build a toy sailboat and the only materials available are common discards and disposables. The inventor might start by thinking about what attributes are important for a floating model and then look around the house for scrap materials and things that are waterproof and can also float. The results of that might include empty plastic jugs, paper and plastic drinking cups, storage containers with snap-on lids, empty milk cartons, balls and balloons, and probably lots of other stuff.

This is like a scavenger hunt with the inventor looking at each object as it is encountered on the search and asking "Is it waterproof? Will it float? How can I turn it into a sailboat?" By looking closely at each object, by handling each one and seeing how it might be made into a boat by cutting, tearing, bending, or doing something to it, each material will begin to reveal if it wants to (or doesn't want to) become a sailboat.

Indeed, one kid inventor discovered that an empty milk carton cut on three sides across the diagonal makes a great floating catamaran boat. When the cut milk carton is folded open, it forms two pontoon hulls in the shape of a "W." To turn it into a sailboat, the inventor made a slit in the middle of the "W" hull and added a paper plate as a sail. This milk carton sailboat cannot only sail swiftly with the slightest breeze, the twin hulls can be loaded with cargo. In this example the invention process was elegant and so was the final design.
Nearly every material, every component, and every product that was created for one particular purpose can also be used to do something else. Sometimes these new uses are even more exciting than the original use. If you mess around with stuff in enough ways, you might discover that paper tubes can become musical instruments, plastic wrap and water make a giant magnifying lens, a length of hose makes a good short-distance telephone, a paper clip bent a special way becomes a building module, and a plastic six-pack carrier can be used to blow streams of big bubbles.

The idea is to learn what the object wants to be, by imagining what it might do differently if it floated on water, if it were three times as big, or if it glowed in the dark. The more ideas you try out, the better chance you will find—or actually invent—an exciting new use for the object. To help in the discovery process, here is a list of words you might start with to see what else an object might want to be. It helps to have the object with you to try out the idea as you think of it—being able to look at the object and handle it also helps generate new ideas.

What else could this be if it could . . .

be worn?
be carried?
be upside down?
be sideways?
get hot?
get cold?
be hung?
moved by itself?
become invisible?
largest?
bright?
brighter?
be soft?
be hard?
be smooth?
be rough?
glow?
be fuzzy?
emit sounds?
be unbreakable?
be thrown away?
be used to build with?
hold something?
protect something?
be a toy?
be connected to something else?
be cut in pieces?
smell good?
smell bad?
be sticky?
have wheels?
be waterproof?
be eaten?
be a work of art?
save time?
be used by pets?

How could you use the object in different places, like . . .
in your bedroom?
at school?
in a hiding place?
in a car?
on a bicycle?
in a specific room?
on the floor?
on the wall?
on the ceiling?
at a restaurant?
in bed?
on a table?
on a boat?
at the beach?
at the park?