

Science Concepts Young Children Learn Through Water Play

Why is water such a compelling source of learning pleasure for most children? This article convincingly identifies why water play is a key science and mathematics medium that enhances young children's learning through discovery.

Carol M. Gross

Young children can spend countless hours playing with water: pouring it back and forth, watching it spill over the edge of a container, blocking its stream, directing its flow, splashing gently, making waves, and pouring some more. When a water table is not available, they can often be found “washing their hands” in the bathroom for long periods of time, mesmerized by the water. Sometimes it is hard for adults to encourage them to leave the sink.

Few children can resist water's attraction.

Few children can resist water's attraction. What is going on here? Water is fascinating, fun, and multifaceted. Children can play with it endlessly. But play, for play's sake, is not water's only value (Crosser, 1994, Tovey, 1993). Indeed, water play is a compelling focus of study for young children (Chalufour & Worth, 2005).

The concepts that young children learn from water play are essential for early childhood educators to be aware of and promote. As educational policymakers and administrators push for more well-defined assessments of learning, teachers need to be able to clearly articulate the specific concepts children learn during all types of play. This article identifies the science concepts involved in a variety of water play activities and the teacher-mediated learning *process* that can accompany and enhance this learning.

Water Play/Water Study

Water and a few inexpensive tools can provide a sensory and learning experience of immense proportions. What is it children get out of their water study, which looks so much like fun? Free play with water can build the foundation for understanding of a multitude of scientific concepts, including those in

- physics (flow, motion),
- chemistry (solutions, cohesion),
- biology (plant and animal life), and
- mathematics (measurement, equivalence, volume).

Mastery of these concepts will support children's understanding of academic subjects in later schooling and life. Science is indeed “serious play” (Wassermann, 1990). Science is “everywhere around us. What can children do to increase their understanding of science? Everything!” (Wassermann, 1990, p. 107). Children inquire, observe, compare, imagine, invent, design experiments, and theorize when they explore natural science materials such as water, sand, and mud.

Science Learning Theory

Science is “a way of exploring and investigating the world around us... not only a way of knowing; it is... a way of doing” (Wenham, 1995, p. 2). Science involves the discovery of factual knowledge (that something is true), causes for what is observed (why something occurs), and procedures (how something is investigated) (Wenham, 1995).

“Science education is a process of conceptual change in which children reorganize their existing knowledge in order to understand concepts and processes...more



Subjects & Predicates

Facilitate children's active involvement in the scientific process by providing materials, encouraging children to observe, predict, describe, and theorize about what they are doing. Raise questions and problems as children play, helping them to grow in their thinking.

completely" (Havu-Nuutinen, 2005, p. 259). The word *process* implies something that happens over time with repeated encounters.

Children benefit the most from in-depth and long-term investigations (Gallas, 1995; Worth & Grollman (2003). Worth and Grollman give vivid, detailed accounts of possible trajectories that projects using the inquiry method can follow. They suggest an investigation of how and where puddles form. They describe an in-depth project about water flow in a pre-K classroom that included creating whirlpools. Some of the children then began to examine small drops of water and how they behave on different surfaces, which led to exploring absorption, as well.

The National Science Education Standards (National Research Council, 1996) call for science to be taught through the inquiry method. Inquiry follows the tradition of hands-on exploration of children's own questions that eventually lead to discovery of scientific concepts.

"Students should be actively involved in exploring phenomena that interest them. These investigations should be fun and open the door to...more things to explore" (American Association for the Advancement of Science [AAAS], 1993, p. 10).

Given these assertions and standards, recurring water play with varying tools and materials is certainly a natural venue through which to support beginning and ongoing science learning. Play IS investigation. Water is the source of life and, as such, can provide almost unlimited learning.

First Experiences

Children's first learning experiences with water, at home and in child care programs, usually include all kinds of pouring. The tools need not be expensive and may even easily be found in the kitchen and recycle bin. Safe, unbreakable measuring cups and small containers (margarine tubs, yogurt cups) of different shapes and

sizes alone can engage very young children. Sturdy funnels may come next. Ladles, straws, basters, and plastic droppers can be new experiences for young children who are old enough to know not to drink the water. These tools are challenging to manipulate correctly so that they draw in and expel the water. All kinds of sifters/colanders can be added, as well. Many children use these simple water-play experiences repeatedly to practice fine motor skills before they move on to more precise or complex activities with other tools.

Tools for Water Exploration

Small, safe, unbreakable, sturdy, recycled when possible

- measuring cups
- containers of different shapes and sizes
- funnels
- ladles
- straws (when children will not drink from them)
- basters
- droppers
- sifters
- colanders

How to Guide the Science Learning Process

Teachers are researchers, designers, relationship orchestrators, listeners, observers, recorders, documenters of children's work, collaborators, and mediators (Lewin-Benham, 2011). Expert early childhood teachers facilitate children's active involvement in the scientific process by providing materials, encouraging children to observe, predict, describe, and theorize about what they are doing. Teachers raise questions and problems as children play, helping them to grow in their thinking.

This is an approach to learning that early childhood educators have

used historically, but has not always been recognized formally as promoting learning. It has been supported by many theorists, including Vygotsky (1978), Feuerstein (2011), Malaguzzi (1993), and many others. Learning happens in the relationships and conversations between novice and experienced learners. Experienced learners facilitate learning by asking questions and commenting as children play (investigate). This approach has been used for decades in Reggio Emilia schools in Italy, now world-renowned for their highly purposeful and in-depth approach to young children's learning.

Lewin-Benham (2011) describes the teacher's role, integrating the Reggio Emilia approach with what she refers to as "other inspired approaches" such as Montessori (1967), the Project Approach (Katz & Chard, 2000), and the Creative Curriculum (Dodge, 2002):

- Create an open-flow schedule with flexible amounts of time for exploration
- Recognize that the environment is a teacher and determines the curriculum
- Engage children in meaningful conversation
- Document children's work and learning
- Assess children's process and progress

How teachers facilitate water play

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Subjects & Predicates

Bubbles form in any water, but break quickly. The bubbles last when the water is mixed with soap because the soap acts as a surfactant and allows the molecules to separate more easily.

Engage in Meaningful Conversations

At strategic moments, during play with water and tools, teachers typically ask intentional questions to extend children's thinking, expand their memory, and help use evidence to support their ideas. This can happen either as children are working, during transitions, or afterwards in a more extended small group discussion (Lewin-Benham, 2011).

Discussion during or after an activity is almost always preferable to discussion before the activity (except for making predictions about what children expect to happen or how much a container holds, for example), because children have more knowledge and experience and can contribute more after having explored the medium and tools. Discussion before the exploration usually involves more telling by the teacher than thinking by the children.

Many of these discussions lend themselves to recording and documentation. Children can help create KWL (know, want to learn, learned) charts, predictions, outcome or comparison lists, charts, and/or drawings and models to demonstrate what they think will happen, what they actually observed or caused to happen, and how the two are alike or different. Use these results to stimulate further discussion with children.

Choose Compelling Science Processes

Sink and Float

The concepts of sink and float are common science curriculum at the early childhood level. However, sink and float encompasses many more sophisticated concepts that primary children can also discover when accessories are placed in the water table (or any large basin) with

intentionality to help children to engage in the scientific process and grow their thinking.

Young children can explore the forces of *buoyancy*, *displacement*, *up thrust*, *porosity*, and *density* for months (see Table 1 for details) with simple materials that are recycled, found in the classroom, or purchased in inexpensive retail stores.

A teacher might begin these explorations with a group of large and small, heavy and light, items that sink or float—challenging the common expectation of young children that large, heavy things sink and small, light things float. An excellent choice is fruits and/or vegetables that children will wash and cut for snack. Children (and even graduate students) are usually delighted, surprised, and confused when they see a large pumpkin float and a lima bean sink! Another possibility is to offer children a large wooden block of wood (that will float) and coins (that will sink).

Children spend many happy hours finding objects themselves to see whether they sink or float. Eventually, they often figure out for themselves, if they are not told, that what something is made of matters and that *shape plays a role in floating and sinking*. For example, children can be given clay or foil to shape into boats and try to float them. Record children's findings from these explorations on simple charts labeled FLOAT and SINK.

The influence of *density* is a concept that children will not usually discover on their own, without some mediation from the teacher. However, conversations about density are more meaningful and memorable when they come after much play. The delight in this activity can go on for weeks, until children tire of it,

Table 1. Science Concepts About Sink and Float

Concept	Definition	Exploration	Meaningful conversation
Buoyancy	an upward-acting force exerted by a fluid that opposes an object's weight	Infant-Toddler—relatively small objects that sink, larger objects that float Pre-K to 2nd—objects chosen by teachers to challenge the obvious; items children choose from school, outdoors, or home	What happened when you put the object in water? Why do you think that happened?
Density	how much material an object has in the space it occupies	Pre-K—small, light objects that sink and large, heavy objects that float K to 2nd—a variety of balls made from different materials: tennis, baseball, metal, Ping Pong, golf	How are these objects different from each other? How are they the same?
Displacement	to move physically out of position	K-2nd—children form clay or foil into different boat or raft shapes, add small objects, and predict how many items it will take to sink their boats	What do you think will happen next? What happened to the water when the boat sank?
Porosity	permeability to fluids	Infant-Toddler to Pre-K—sponges, cotton, cloths for everyday cleaning or for exploration in a low container of water	What happened when you squeezed it? What did you find out about this material? Which material held the most water?

having investigated as far as they can, for the moment.

The idea of objects being *porous*, and whether porous objects sink or float, is another concept embedded in children's exploratory water play. Children can submerge sponges, cloths, and/or paper towels in water,

then squeeze them over cups to see what happens when water is absorbed into an object. Find out which item holds more water. Children can investigate this and related ideas over and over again at clean-up time as they wash the tables for lunch, or as an activity in itself.

Table 2. Science Concepts With Bubbles

Concept	Definition	Exploration	Meaningful conversation
Cohesion	force that holds together the molecules in a solid or liquid	K, 1st—with a dropper, continue to add water to a full cup of water to see how many drops make it overflow	How many drops will it take to overflow? What do you see the water doing? How do you think the water can do that?
Surface tension	molecules on the surface are attracted to molecules from all sides and below, but not from above	1st, 2nd—use a penny and dropper to see how many drops of water it takes to cover the surface of the penny	How many drops will the penny hold? How many drops do you think it will take to make the water overflow?
Surfactant	chemical agent that can reduce surface tension of the liquid in which it is dissolved	Pre-K, K—add soap to water	Compare bubbles before and after adding soap. What did we change to make the bubbles last longer?
Color spectrum	the distribution of colors produced when light is dispersed by a prism or bubble	Pre-K to 2nd grade—try coloring bubbles with paint or food coloring	What color are the bubbles at first? What color do you think they will be if (color) is added? What do you see? Why do you think the rainbow happened?
Sphere	perfectly round 3-dimensional shape	Pre-K to 1st—mix water with Dawn or Joy dish detergent. Create bubbles with all kinds of objects with holes.	What bubble shape do you think this tool will make? What shapes do you see that bubbles form?
Transparent	transmitting light, able to see through	K, 1st—experiment with clear objects such as plastic tumblers; bubbles	Why do you think we can see through (items or) the bubbles?
Dissolve	become an inseparable part of a solution	K to 2nd—provide salt, water, oil, flour, vinegar for children to mix with water	Where did the (mixed item) go? How can we get it to come back like it was? Let's try!

Bubbles

Similarly, play with water and soap holds a number of complex science concepts for exploration such as *cohesion*, *surface tension*, *surfactants*, *light spectrum*, and others (see Table 2). Some dishwashing detergents, particularly Joy® and Dawn®, when mixed with three or four times as much water as soap in a small basin, will produce hundreds of satisfying bubbles. An ounce or so of corn syrup, while not necessary, can add to the lasting quality of the bubbles.

Children use common household or classroom items like these to create bubbles:

- colanders
- slotted spatulas and spoons
- unused fly swatters
- screens
- large-hole buttons

Why are bubbles formed? Cohesion happens when water molecules stick to each other. One way children can find this out is, again, through a mediated process. Children fill a cup of water to the brim. With an eyedropper and another container of water, they continue to add water to the cup drop by drop until it overflows. Children who can count to 50 or so (as some kindergartners and most 1st graders can), can predict and then see how many drops it takes to make the water spill over the edge of the cup. Children are especially excited when the water forms a dome above the edge before it finally spills.

Young children will eagerly do this many times before they fully believe it and internalize the scientific understanding, whether they remember the word *cohesion* or not.

Actually, bubbles form in any water, but break quickly. The bubbles last

when the water is mixed with soap because the soap acts as a *surfactant* and allows the molecules to separate more easily. Families and administrators will be especially impressed if children remember that word. They learned it through play!

If children are asked about the shapes bubbles come in, they may play with and blow bubbles for days before they realize that, no matter what shape tool they use, the bubble always comes out a *sphere* (except when it is touching another bubble). Later, when children are older, they will learn that this is the case because of the mathematical properties of shape. For now, it simply makes them wonder.

If a teacher asks what color children think the bubbles will be if food coloring or paint is added to the soapy water, they may be surprised at what they discover. Again, children will need time to play with the colored bubble solution before they conclude that bubbles are always *transparent*, except for the rainbow at the edge. The rainbow is the *color spectrum* created by the reflection of light on the bubbles.

To record bubble shapes, blow them onto plain paper or use the paper to catch them as they fall. What happens when the bubbles pop on the paper?

Mixtures and Solutions

Other *mixtures* and *solutions*, equally easy and safe to form, can become fodder for children's exploration process. This work leads to the ideas of *emulsion* and *suspension*, in addition to further understanding of *surfactants* and more (see Table 3).

To offer children ways to explore solutions, first ask families to help collect clean, clear recycled plastic bottles with tops, such as water and soda bottles.



Nancy P. Alexander

Free play with water can build the foundation for understanding of a multitude of scientific concepts, including those in physics, chemistry, biology, and mathematics.

Find a few sturdy funnels. Ask children to help prepare bowls of salt, oil, water, or other substances.

Record responses as children predict whether the two substances will blend together, and then mix and see what happens! Which items *dissolve*, which mix while being stirred but then separate (are *suspended*), and which do not mix at all.

At another time, after much experience with *mixtures*, *solutions*, and *suspensions*, children can make mayonnaise. They will discover that some seemingly *unblendable substances*, such as oil and egg, can mix and stay mixed when added slowly while stirring. Offer the word *emulsion*, which describes this type of mixture.

Children are delighted to learn these technical terms. Of course, enjoying big words is not necessary to children's understanding of the concepts, but learning them now adds to the integrity of the learning process.

Children can mix water and cornstarch to play with, the concoction many teachers are familiar with known as Oobleck or Goop. Is Oobleck *solid* or *liquid*? One principle of scientific investigation is that, if teachers refrain from teaching/telling answers to questions like this, children will continue to explore. After an answer is given, exploration and learning often come to an end. Sustain learning by refraining from the urge to answer such questions!

Table 3. Science Concepts for Study With Solutions

Concept	Definition	Exploration	Meaningful conversation
Solution	homogeneous mixture of two or more substances	Pre-K to 2nd—bottles or bowls and substances for children to mix; e.g., water, pepper	Where did the salt (flour, etc.) go? How do you know?
Suspension	system in which particles are dispersed through a less dense liquid or gas from which they are easily filtered but not easily settled because of viscosity or molecular interactions	Pre-K to 2nd—containers with oil and vinegar, or water and salt, cinnamon, or other items for children to try to mix	Which ones mix? Which ones don't mix? Why do you think some do mix and some don't mix?
Emulsion	mixture of two unblendable liquids	Pre-K to 2nd—oil and egg to make mayonnaise	What happens when we just put them together? How could we get them to really mix? (add gradually while stirring)
Mixture	when two or more substances are combined, each retains its own identity	3 year to 2nd—substances for children to mix and bowls for mixing	What do you think makes some things mix and others not?
Absorption	to take in	All ages—use sponges, cloths, or paper towels to mop up water during cleaning or play	Where do you think the water went? Which one holds the most water?
Solid	of definite shape and volume	Infant to K—make or find ice to hold and watch while it melts	How does the ice feel? What is happening to it? How long do you think it will take to completely melt?
Liquid	a characteristic readiness to flow and little or no tendency to disperse	Infant to K—all water play or other liquid play, such as Oobleck (see non-Newtonian)	What else do you know that is solid? What are some other liquids?
Gas	the state of matter distinguished from solid and liquid by its low density and viscosity, expands and contracts with changes in pressure and temperature, diffuses easily, and is distributed uniformly	All—place bowls of water in different places (window sill, outdoors, refrigerator) to see which ones evaporate faster	What happened to the water? Where did it go? How do you know?
Evaporation	the process of becoming a vapor	Toddler to pre-K—paint with water on a chalkboard, sidewalk, fence, or brick building in summer	What happened to the wetness?
Non-Newtonian	a fluid (yogurt, mud) whose flow properties differ from those of Newtonian fluids (water), usually in viscosity	Toddler to 1st grade—mix cornstarch and water in roughly equal proportions	Is this stuff liquid or solid? Can we make a ball of it?
Viscosity	thickness, semi-solid quality	Toddler to pre-K—explore water, ketchup, paint, honey	How are these the same? Different?

Cooking and the effect of water in recipes is another appealing area for exploration. When children measure, mix, freeze, and more, cooking becomes full of science learning, as well as math and literacy. This is a topic for another article.

Water Flow

Flow is another concept that children can understand through the simple process of playing with intentionally chosen materials. Provide *transparent* plastic pipes and connectors, found in a hardware store. Children can build pipe systems, and then pour water and watch it flow down through their system into the water table or a bucket (Dinwiddie, 1993; Sible, 2000).

Children are fascinated by making water flow. Provide them with opportunities to understand how flow works and what stops it as they solve problems over and over in different ways at a water table or outdoors. One school offered these materials outside so children could make longer systems all over the playground. The teachers then took children to the school basement to see the pipe system. A more complex water system that children can help design is shown in Figure 1.

Measurement

Children can, of course, learn much about *measurement* through water play. The simplest materials for this are containers of various sizes for pouring. Teachers can ask which container has *more* water, which has *less* and which is the same, or *equivalent*.

Then, children can be asked *how many* of one container or baster it will take to fill a larger bottle. They will often do this over and over, comparing their answers with each other. They will be surprised if they notice that it is the same number for

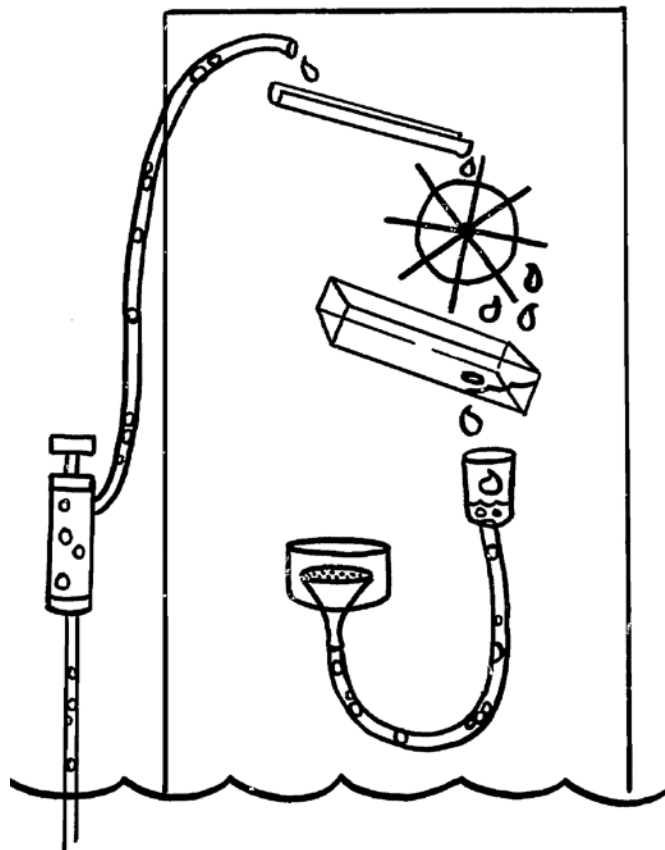


Figure 1. Water flow device that includes a mechanical pump to push the water upward, flexible pieces of transparent piping so the flow can be seen, a wheel to continue the water's progress, and containers to catch the water.

each container when they are of different shapes.

When children are ready to consider more precise measurements, add marks on plastic containers with fingernail polish for half- and/or quarter-full places to extend the mathematical learning. Measuring cups, in various sizes, will also enable children to use more accurate measuring and introduce both the metric system and *fractions*.

Pouring alone provides practice in *counting*, *one-to-one correspondence*, *fractions*, *volume*, *conservation*, and many other math and science concepts. Young children may not yet understand the concept of *conservation*, but their experiences with water play will move them closer toward that comprehension. This play/study will fill hours of explora-

tion for children from 4 year olds to at least age 7.

Evaporation

Young children can explore *evaporation* in numerous ways through play. As mentioned earlier, they can *investigate* it while washing the table after lunch or any messy activity. They can explore it outside in summer, with paint brushes on warm bricks or other dark surfaces where they can watch the water evaporate almost instantaneously. Children can examine evaporation inside by painting with water on a chalkboard and watching it evaporate, albeit a little more slowly. The risk of a slippery floor can be eliminated and evaporation can be observed again while mopping. Make sure to have small mops so children can participate.

* * *

For a responsive, intentional, and reflective teacher, these concepts are only the beginning of the science that children can learn from water play/study.

Water play can branch into social studies for older preschool and elementary children in investigations of waves, rivers, lakes, oceans, the environment, and even natural disasters (Davis, 2005; Dove, Everett, & Preece, 1999; Frost, 2005; Hendrick, 1997; Maynard & Waters, 2007; Trisler, 1996).

Children can use experiences with water as opportunities for art and creativity, as well (Dove, Everett, & Preece, 1999; Szekely, 2003). When children paint with water on a chalkboard and it evaporates quickly, they can easily change their work or try another technique. Painting with water on a chalkboard is also a good introduction to art and painting before children ever use paint, or as a beginning to paint at the start of the year. With water, children explore the possibilities of movement with a brush. They can be less concerned with drips and spills as they express ideas and feelings through art media. Children can also experiment with mixing colors in water without the finality of doing it on paper.

The social learnings from water play include collaboration, concentration, turn taking, problem solving, perseverance, self-regulation, and more. Social skills may be one of the most long-lasting learnings children gain through water play, possibly helping them develop these attributes for a lifetime.

Young children also gain physical learning through water play, such as precision in pouring, eye-hand coordination, and other skills. When children pick up buckets or other objects filled with water, they build

muscle strength.

Water play is particularly useful and therapeutic during the learning of children who have special needs (Dodge, 2002; Goltsman, 1997; Texas Department of Human Services, 2001). Water often helps children with behavior problems calm themselves. It is multisensory for children who have vision and hearing impairments. It is a more forgiving, less frustrating material than other media, especially for children with learning disabilities.

Children's learning from water play/study clearly is multidisciplinary. It can help children further their understanding of how the world works, where things come from, and how things are made. Water study belies the notion that young children have a short attention span. Exploring with water is captivating, engaging, engrossing and absorbing to almost all children and even the adults who care for them.

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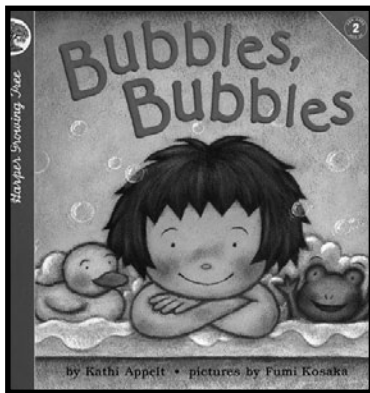
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Extend

These Ideas With Books

Connect “Science Concepts Young Children Learn Through Water Play” With a Children’s Book

by Janie H. Humphries



Bubbles, Bubbles

Written by Kathi Appelt. Illustrated by Fumi Kosaka.
2001. Hong Kong: Harper Festival.

The delightful, simple illustrations of *Bubbles, Bubbles* enhance the rhyming text of the book. The text and pictures illustrate the fun a child can have in soapy, bubble-filled bath water. Along with a yellow duck and a green frog, bath bubbles are enjoyed while tummy, knees, and elbows are scrubbed clean. The book shows how a child can use bubbles to make a moustache, a scary hair-do, or a hat for ducky while getting squeaky clean. Saying good-bye to dirt can be fun.

Classroom Ideas!

Bubbles, Bubbles introduces a variety of learning activities children can have with bubbles and water. It illustrates the fun children have when they play and learn using water and bubbles.



MOVEMENT & MUSIC: On a sunny day, go outside. Half the children have jars of bubble solution and wands to make bubbles. Put on a favorite active song, such as “Singing in the Rain,” *Rock n’ Roll Songs That Teach With The*

Learning Station, or “Kids Pop Party Hit” by Drew. Encourage the children not making bubbles to dance to the music and pretend the bubbles are rain.



SCIENCE: Children explore ways to make bubbles. They can make strong, big bubbles using 1/8 to 1/4 cup of liquid detergent (Dawn or Joy works best), 1/2 cup of water, and 1 Tbsp. of clear corn syrup. Experiment with making

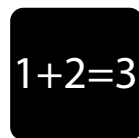
bubbles by using items that have holes in them such as colanders, fly swatters, and buttons. Plastic soft-drink holders, plastic berry baskets, or rings from canning jars make fun large bubbles. Ask children to predict what shape the bubbles will be when made with different items. (They will always be spheres unless the bubble is touching other bubbles.)



LITERACY: While making and playing with bubbles, use and introduce terms such as *cohesion*, *solution*, *mixtures*, *suspension*, *sphere*, *dissolve*, and *transparent*. Children enjoy using these terms and families are pleased to hear the terms.



ART: Make soap paint by mixing 2 Tbsp. tempera paint, 2 Tbsp. liquid detergent, and 1/2 cup water. Use a straw to blow gently into the soap mixture. If the mixture is too thick, add more soap. Blow bubbles until they come to the top of the container. Place a sheet of white construction paper over the container. As the bubbles pop, they will leave rings on the paper. Place the paper over several different colors to get a tie-dye effect. Don’t let the paper get too wet.



MATH: With children, count how many bubbles are in the air at one time. Together, compare the number of bubbles. How do you know which numbers are smaller or larger? Children can write the numerals with sidewalk chalk for comparison. When children make their own bubble mixture or soap paint, they better understand the concept and need for measurement, so they are solving math problems.



SOCIAL/EMOTIONAL SKILLS:

Working together to reach a goal is an important skill. Identify children who can share tasks and help children who need help making these decisions. Recognize different tasks that children

complete to reach a goal.

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