A young child starting preschool brings a sense of wonder and curiosity about the world. Whether watching snails in an aquarium, blowing bubbles, using a flashlight to make shadows, or experimenting with objects to see what sinks or floats, the child is engaged in finding out how the world works.

It is not exaggerating to say that children are biologically prepared to learn about the world around them, just as they are biologically prepared to learn to walk and talk and interact with other people. Because they are ready to learn about the everyday world, young children are highly engaged when they have the opportunity to explore. They create strong and enduring mental representations of what they have experienced in investigating the everyday world. They readily acquire vocabulary to describe and share these mental representations and the concepts that evolve from them. Children then rely on the mental representations as the basis for further learning and for higher order intellectual skills such as problem solving, hypothesis testing, and generalizing across situations.

While a child’s focus is on finding out how things in her environment work, her family and teachers may have a somewhat different goal. Research journals, education magazines, and the popular press are filled with reports about the importance of young children’s development of language and literacy skills. Children’s natural interests in science can be the foundation for developing these skills.

Back in February, Mrs. O’Shea’s preschool children had explored the concept of light and shadows. They collected many types of materials to see which ones would create a shadow in the bright light and which ones the light would just pass through. After several days of experimentation, they realized that while opaque materials create shadows and transparent materials allow light to pass through easily, there are some things that don’t fit either category. These materials allow some light to pass through (although not as much as window glass) and they cause very light shadows. Later in the school year, a visitor to the classroom was present during snack time when the children were trying new clear strawberry flavored Jello with stars and moon shapes in it. The visitor overheard the following conversation among the four-year-olds:

“It’s transparent!” remarked one little girl with surprise.
“No, it’s translucent,” countered another girl.
“Why do you say it’s translucent?” asked Mrs. O’Shea.
“Because you can only see through it a little,” the girl responded.

Whereas many adults think of science as a discrete body of knowledge, for young children science is finding out about the everyday world that surrounds them. This is exactly what they are interested in doing, all day, every day.

In the preschool classroom or in the university research laboratory, science is an active and open-ended search for new knowledge. It involves people working together in building theories, testing those theories, and then evaluating what worked, what didn’t, and why.
On a bright fall morning, a group of three-year-olds takes
a walk and observes fall leaves dropping from the trees
and blowing around the school yard. They come inside to
read a book. The book contains a picture of a rake. Few of
these urban, apartment-dwelling children have ever actu-
ally seen a rake. The teacher asks what it is and what it
might be used for. A real rake is brought in as the discri-
sion proceeds and the children speculate:
“Could you scratch the grass.”
“Use it for a back scratcher.”
“Throw it in the garbage.”
“I clean the leaves!”
All of the children’s ideas are considered and a bag of
fall leaves is dumped on the classroom floor. The children
are given opportunities to feel the leaves, kick the leaves,
and use the rake. Coming back together as a group, they
reevaluate their earlier theories and decide that a rake can
be very helpful in making a pile of leaves to jump into.
Science, language, and literacy have all combined in a
meaningful learning experience for the children.

**A science-based curriculum**

For the past seven years, the authors have been in-
volved in creating, implementing, and refining a science-
based preschool curriculum encompassing both content
and process goals. Known as ScienceStart! this full-day,
full-year curriculum is currently being field-tested at a
number of sites in Rochester, New York. (Throughout,
when we refer to one of “our” classrooms, we mean a
classroom that is using ScienceStart!) The major content
goal of this curriculum is for children to develop a rich,
interconnected knowledge base about the world around
them. The primary process goal is to foster and support
the types of typical intellectual development that charac-
terize the preschool years. These include receptive and
expressive language skills, skills in self-regulation—
particularly attention regulation—and skills in problem
identification, analysis, and solution. Several theoretical
assumptions that are widely shared by early childhood
professionals underlie these goals:

- Young children are active, self-motivated learners who
  learn best from personal experience rather than from
decontextualized linguistic input. (e.g., French 1996;
- Young children construct knowledge through participa-
tion with others in activities that foster experimentation,
problem solving, and social interaction (Gallas 1995;
Chaille & Britain 1997).
- Young children should be allowed to exercise choice in the
  learning environment (Bredekamp & Copple 1997).
- Children’s social skills develop best when they have
  opportunities to learn and practice them in the context of
meaningful activities (e.g., Katz & McClellan 1997).

Science in our preschool classrooms is not a compli-
cated process, nor is it an activity that occurs separately
from the normal classroom routine. Almost all young
children in almost all environments “do science” most of
the time; they experience the world around them and
develop theories about how that world works. At the
easel, a boy may be using blue and yellow paint. Suddenly,
he notices that as he paints, the color green appears. The
child has the opportunity to theorize about color mixing:
“Does this always happen with blue and yellow paint?”
“Can I make any other colors with blue and yellow paint?”

In any preschool classroom, the process of formulating
theories based on experience happens in the art, block,
and dramatic play areas, and during outdoor play. The
difference for the children in our classrooms is that adults
work to create an environment that is integrated and
coherent rather than disjointed. Thus, children explore
the same phenomenon—in this case, color mixing—in
different parts of the classroom, particularly in activities
that involve language and literacy.

In the leaf raking example described earlier, the children
took a walk outside to see leaves blowing, then read a
story about leaves, then raked leaves in the classroom.
They also had other opportunities that day to explore
leaves. They could decorate leaf-shaped cookies with a
variety of fall-colored frosting, paint tree and leaf pictures
at the easel, sort real leaves by shape or color, examine
leaves with a magnifying glass, and dance like leaves in the
wind. Science, for all the children, was a creative and ex-
ploratory process, one in which they could use many
forms of knowledge to build theories about their world.
While talking with them about what they were doing, the
teacher not only involved the children in a conversation,
but also offered them relevant vocabulary and modeled
ways of thinking about and talking about their experi-
ences.

**Childhood curiosity leads to real science**

Many early childhood teachers are hesitant about
introducing science in their classrooms, often because of
their own unpleasant science education experiences.
When asked if they teach science, these educators might
point to the plants on the shelf or the collection of stones
and shells and indicate that science is taking place “over
there.” Other teachers see science as some kind of magic
trick to perform on a Friday afternoon when everyone is
tired and bored. They bring out the baking soda and
vinegar to “make a volcano.” While the children may be
amazed and amused by this activity, it does not build
accurate knowledge and does not represent real science.

Real science begins with childhood curiosity, which
leads to discovery and exploration with teachers’ help and
encouragement. It involves three major components: con-
tent, processes, and attitude. Young children prize infor-
mation about the world around them, yet an emphasis on
content is not enough. Although many people view science as a body of knowledge (facts and formulas) that scientists learn and use, in reality this body of knowledge is constantly changing as new discoveries are made. Young children, like scientists, need to practice the process skills of predicting, observing, classifying, hypothesizing, experimenting, and communicating. Like adult scientists, they need opportunities to reflect on their findings, how they reached them, and how the findings compare to their previous ideas and the ideas of others. In this way, children are encouraged to develop the attitude of a scientist—that is, curiosity and the desire to challenge theories and share new ideas. Scientific exploration presents authentic opportunities to develop and use both receptive and expressive language skills.

In Miss Chrissie’s classroom, one morning in April, an observer asked two four-year-old girls what was inside the cups on a windowsill. The girls explained that they had planted seeds and were waiting for them to grow. The observer asked how long it would take and was told, “Maybe a few days.” The observer asked why it would take so long and was told, “Growing takes time. You need to be patient.” The girls then explained about the plant’s need for water and light. The observer looked outside and pointed out to the girls that there were grass, trees, and flowers outside that also needed water. The girls reassured her that the rain would water those plants. While this may appear to be a simple and everyday conversation (as indeed it should be), these girls were using their classroom science work to make observations and hypotheses and communicate these clearly to a classroom visitor.

The importance of a coherent approach

In Talking Their Way into Science, Karen Gallas (1995) explains that young children must be allowed to construct their knowledge about science by imagining possible worlds and then inventing, criticizing, and modifying those worlds as they participate in hands-on exploration. They must be encouraged to develop possible theories about their own questions and then proceed to investigate these theories within the classroom learning community. For this to happen, the opportunity for in-depth and long-term investigation through a variety of activities—what we term coherence—is essential. The girls whose seeds were growing on the windowsill had opportunities to over- and underwater plants; paint bouquets of flowers at the easel; take plants apart to investigate the roots, stems, and leaves; and make and eat a salad containing leaves, roots, stems, and flowers. They read many books about plants and participated in discussions with peers and adults about what they were learning.

Many, and perhaps most, preschool classrooms have little coherence from day to day. For example, teachers following a “letter of the week” approach may have children investigate dinosaurs one day, dig in dirt the next day, and make a dessert the third day. Each activity is developmentally appropriate and enjoyable, but other than the letter D they have nothing in common.

In contrast, in a coherent approach to early childhood education, each day’s activities build on those of the day before and provide a basis for those of the following day. Teachers who follow a science-based curriculum find that they can maintain a focus for 8, 10, or even 12 weeks. For example, the ScienceStart! unit on color and light takes place over a 10-week period. Children explore mixing colors to make new colors, investigate light sources and how shadows are made, observe how light travels, and finally study the cycle of day and night. While each day brings new activities and new theories, the days fit together into a coherent pattern that offers children the opportunity to revisit ideas and activities, to build a knowledge base, and to use knowledge gained on one day as the foundation for the next day’s exploration.

It might seem that learning about air could be difficult for four-year-olds. After all, they can’t see it or even really get ahold of it. But we have found that after spending the previous eight weeks discovering the properties of solids and liquids, preschool children have a lot to say about air.

“I know it’s there ’cause I can feel it in my hair.”

“The bubble has my air in it!”

“Air isn’t like a solid ’cause it has no shape. It’s the shape of the balloon.”

“You can’t pour it and it doesn’t make a mess on the floor.”

While children’s theories are seldom complete and will go through many revisions, the coherence of the curriculum offers them opportunities to make in-depth explorations over an extended period of time.

Science learning: Something to talk about

Several years ago, the local director of state-funded preschool programs was asked why she was spending money on inservice training in the area of science when, after all, “everyone knows” that language and literacy should be the focus during preschool. Agreeing that language and literacy were important goals for young children, the administrator pointed out that language and literacy learning must be about something.

After hearing this story, we asked our teachers, who had been using a science-based curriculum for several years, to respond to the Why science? question based on their own observations and experiences. The resulting conversation was condensed into 10 good reasons (see Beyond
opportunities for a variety of preliteracy and literacy experiences. There are opportunities for receptive and expressive language, for consulting text, and for producing graphic representations of ideas (both drawn and written). So, in our classrooms, the daily literacy activities are integrated into the science learning. As in many other preschool classrooms, our science-focused teachers read to their children every day.

Children work together to create written reports about their scientific explorations. They make graphs and charts, create books, and dramatize ideas. Many children keep science journals to record data. For example, in our classrooms three- and four-year-old children from families living in poverty used drawings and words to document the growth and changes that occurred as their caterpillars transformed into painted lady butterflies. Strong and meaningful learning takes place as children participate in language and literacy experiences about something of real significance to them.

**Conclusion**

Some teachers want to take steps to introduce more science into their education programs, but they are unsure about what to do. These same teachers are often comfortable with cooking and art. It is possible to explore many science activities through cooking and art. A coherent unit can be developed in which the same topic is explored through three activities—science, art, and cooking. For example, the effects of air could be explored by making meringue cookies (cooking), by using a straw and hairdryer to blow a marble across a page containing wet paint to create an air picture (art), and by taking a collection of items and predicting which can be moved by blowing through a straw (science).

Teachers who increase their understanding of what science is at the preschool level will come to see that science can be incorporated into many, if not most, of the activities that they already do. Science itself is not an activity, but an approach to doing an activity. This approach involves a process of inquiry—theorizing, hands-on investigation, and discussion.

Over the past seven years, we have worked with almost two dozen teachers who were implementing ScienceStart! predominantly with children from families with low incomes, including children with special needs. We have found consistent reactions among these teachers. They find that an emphasis on hands-on science leads to increases in children’s level of engagement, in language use and language skills, and in positive peer interactions. Families have been surprised by their children’s abilities to learn science and report that their children often transfer content knowledge and the process of inquiry from pre-

As children were gathered around the duck egg incubator in Mrs. Toot’s classroom, the teacher asked them what they knew about ducks. The children speculated about what ducks eat, and asserted that ducks quack and can swim. One girl added that they have “skin between their toes.” The discussion continued about what covered their bodies, with some children arguing that it was fur, while others contended that feathers cover a duck. No agreement was reached, and the suggestion was made that they needed a real bird to look at. Mrs. Toot arranged a classroom visit from a parakeet while they waited for their duck eggs to hatch.

Investigations of the everyday world offer many opportunities for a variety of preliteracy and literacy experiences. Researchers have found that children are most likely to learn language and literacy skills when they have opportunities to use these skills in authentic situations (e.g., Goodman 1984; Teale & Sulzby 1984). The problem-solving approach associated with scientific inquiry is rich in language. Teachers can support children as they acquire and practice increasingly sophisticated language skills. The group discussion may be completed in 5 minutes or may continue as long as 45 minutes. Throughout this period, participants are involved in coherent, contingent conversation. Whether active contributors to the conversation or listeners, children gain important practice in how to maintain conversational coherence, switch and return to topics, use language to move between the past, present and future, and translate between linguistic and mental representations.

To speak, children must translate their own mental representations into linguistic output that can be shared with others. In listening, they create mental representations based on someone else’s language. Translation between linguistic form and mental representation is generally difficult for young children, but in this case it is supported and facilitated by the hands-on experience being shared by the listener and speaker.

As children were gathered around the duck egg incubator in Mrs. Toot’s classroom, the teacher asked them what they knew about ducks. The children speculated about what ducks eat, and asserted that ducks quack and can swim. One girl added that they have “skin between their toes.” The discussion continued about what covered their bodies, with some children arguing that it was fur, while others contended that feathers cover a duck. No agreement was reached, and the suggestion was made that they needed a real bird to look at. Mrs. Toot arranged a classroom visit from a parakeet while they waited for their duck eggs to hatch.

As children were gathered around the duck egg incubator in Mrs. Toot’s classroom, the teacher asked them what they knew about ducks. The children speculated about what ducks eat, and asserted that ducks quack and can swim. One girl added that they have “skin between their toes.” The discussion continued about what covered their bodies, with some children arguing that it was fur, while others contended that feathers cover a duck. No agreement was reached, and the suggestion was made that they needed a real bird to look at. Mrs. Toot arranged a classroom visit from a parakeet while they waited for their duck eggs to hatch.
school to the home environment. For example, while in the backyard with his mother, one three-year-old asked, “What do you think will happen if we add water to this dirt? What do you think we will get?”

In 1993 the American Association for the Advancement of Science published *Benchmarks for Science Literacy*, a compendium of specific science goals for K–12 grade levels. The use of a coherent, hands-on science curriculum provides preschoolers with the opportunity to meet virtually all of the benchmarks described for children in the K–2 range. For example, at a very general level, the benchmarks for kindergarten through second grade are as follows:

Students should be actively involved in exploring phenomena that interest them both in and out of class. These investigations should be fun and exciting, opening the door to even more things to explore. An important part of students’ exploration is telling others what they see, what they think, and what it makes them wonder about. Children should have lots of time to talk about what they observe and to compare their observations with those of others. A premium should be placed on careful expression, a necessity in science, but students at this level should not be expected to come up with scientifically accurate explanations for their observations. (AAAS 1993, 10).

Most young children bring curiosity and wonder to the early childhood setting. Teachers need only capitalize on these characteristics to make science learning come alive every day. Science learning provides a rich knowledge base that will become an essential foundation for later reading comprehension. It also provides the foundation for meaningful language and literacy development.

References


Please write to the authors to receive an extensive list of fiction and nonfiction children’s books for use in science units on properties of matter (liquid, solid, gas, and change) and color and light: Lucia French, Warner School, University of Rochester, Rochester, NY 14627

Copyright © 2002 by the National Association for the Education of Young Children. See Permissions and Reprints online at www.naeyc.org/resources/journal.