Worms, *Shadows,* *and* Whirlpools

SCIENCE IN THE EARLY CHILDHOOD CLASSROOM

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PART ONE

Principles and Practices Essential to Quality Science Programs

CHAPTER 1

The Science Program in the Early Childhood Classroom

The Science Program

High-quality science programs for children ages three through five are based on an understanding of how children learn, what they are capable of learning, and appropriate science content. In such programs, science is an integral part of the classroom, supporting and supported by the overall goals for young children. In the hands of a skilled teacher, a good science program emerges from a carefully designed environment, clear goals, and children's interests, questions, and play. Science is not confined to a science table or focused on learning facts. Nor is it found in projects that focus on a narrow topic that does not involve direct experience, such as a study of bears or penguins.

Given the importance of community and family, and the individuality of each teacher and child, there is no single best science curriculum or program, but a high-quality early childhood science program always reflects the following characteristics:

- *It builds on children's prior experiences, backgrounds, and early theories.* All children come to school with experiences and the ideas and theories they have constructed to make sense of their surroundings. Some of these early conceptions do not reflect established scientific theories. However, they may reveal a significant capacity to reason from experience and knowledge. For example, in one of the stories in this book, children study a tree. Observing the defoliated tree in the late fall sparks a classroom discussion about whether the tree is alive. While some children had not considered the tree to be

alive even with its leaves, most agreed that without leaves, it was certainly dead. Some of these children had likely reasoned that the living things they knew all moved, thus the tree was not alive. Others with experience with dead plants "knew" that dead trees had no green leaves, thus this tree was dead.

A study of children's early theories leads one to recognize and value how children use their experiences to create logical explanations for how the world works. A good science program provides children with opportunities to share their ideas in multiple ways through both actions and words. Rather than being designed to correct early ideas, teach information, or provide explanations, new experiences provide children with opportunities to broaden their thinking and build new understandings.

- *It draws on children's curiosity and encourages children to pursue their own questions and develop their own ideas.* In an environment with carefully chosen materials and many opportunities to explore and ponder, children will raise many questions both in words and in actions. For example, in one of the stories in this book, the classroom terrarium filled with worms elicited a wide range of questions including, "How do worms hug? Do worms have feet? How do worms have babies? Do worms fight?" In the physical sciences, where children interact directly with materials and events and feedback is immediate, questions may focus more directly on experimentation. For example, at the water table, a child asks, "How do I get water in [this tube]?" And sometimes a child's question is in her actions. The child who carefully makes her ramp steeper before rolling her ball down may be wondering, "What will happen if I make this ramp steeper?"

  In a good science program, children are encouraged to actively pursue such questions as "How do I get water in the tube?" or "What will happen if I make this ramp steeper?" Other questions that cannot be explored through close observation and simple experimentation, such as "How do worms have babies?" can be answered using books or other resources. Still others, such as "Why is the sky blue?" are best left for children's own discussions.

  In good science programs, questioning, trying things out, and taking risks are expected and valued. There is a balance between children's pursuit of their own interests and ideas and the pursuit of

questions and ideas generated by other children or the teacher herself.

- *It engages children in in-depth exploration of a topic over time in a carefully prepared environment.* Time is a critical component of a good early childhood science program. When children explore a few concepts repeatedly in many different ways, they have the opportunity to think, analyze, and reflect on their work. Thus, they are able to organize what they know into deeper and more powerful theories or ideas. The teachers highlighted in this book engage their children in science studies that last for weeks, if not months. One-week projects or twenty-minute choice times simply cannot provide sufficient time for children to explore deeply.

  Carefully selected materials are fundamental, creating many possibilities for children's explorations of science concepts and the development of the skills and processes of scientific inquiry. For each area of study, children need materials that they can use in multiple ways and that lead to interesting challenges and events. For example, during an exploration of water flow, children can use materials such as tubes, connectors, cups, funnels, and basters to create many ways for water to move. They also need tools such as magnifiers, measuring devices, and clipboards for observation, measurement, and the gathering and recording of data.

  At the same time, materials that detract from the particular focus may need to be removed for a while. For example, removing the dolls and dishes from the water table provides space for other materials that highlight water flow. Teachers may also need to remove those items that are less open-ended. For example, a water wheel allows for only pouring water into the opening at the top to watch the wheel spin. There is little opportunity to actually control the flow of water or how it hits the wheel.

- *It encourages children to reflect on, represent, and document their experiences and share and discuss their ideas with others.* Direct experience with materials is critical but is not enough. Children also need to reflect on their work. They need to analyze their experiences, think about ideas such as patterns and relationships, try out new theories, and communicate with others. These processes allow children to think in new ways about what they did, how they did it, and what is significant to them.

Good science programs encourage children to document and represent their work in multiple ways—through drawings, dramatization, 3-D models, and dictation. Their teachers document as well, using photographs, video, drawings, and words. They use the documentation with children to help them reflect on their work. For example, a teacher might use children's drawings to help children describe and think about the role of different parts of plants they have observed.

Good programs also encourage ongoing discussion among children, between teacher and child, and in structured small- and large-group discussions. Such science talks are key, helping children to clarify their thinking with words and use evidence to support their developing theories, while learning from the perspectives of others.

- *It is embedded in children's daily work and play and is integrated with other domains.* A good science program is skillfully integrated into the total life of the classroom. Science may be the focus for a major project, such as living things or building structures. Science work may result from answering questions or exploring interests that emerge as children are cooking, looking at a book, painting, or

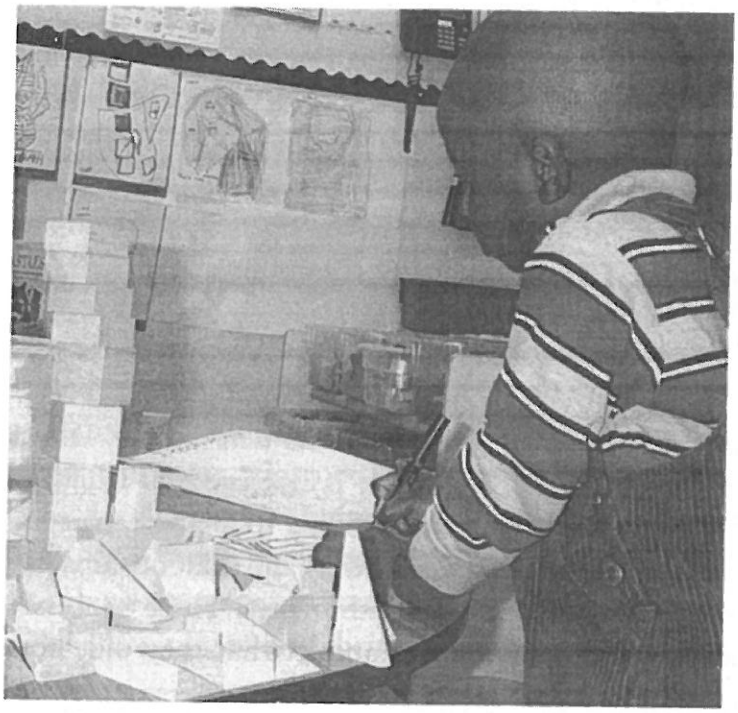

Figure 1–1
Three-Year-Old Malek Drawing the Tower He Just Built

talking about something from home. Children's play also can lead them to pursue science ideas. Sailing boats at the water table can lead to exploration of what sinks and what floats. Building a cave for the classroom bear can serve as an impetus for exploring the challenges of making strong buildings and roofs that span significant distances.

Science explorations are also integrally related to other domains. Many early mathematical ideas, such as number, pattern, and shape, are part of science, as are skills of counting and early measurement. Children sort their leaves by shape, compare the length of their worms and the height of their block towers. Scientific inquiry, mathematical problem solving, and technological design all take place as children build an environment for a worm, make shadow puppets, or create drums that have different sounds.

By its very nature, science requires language, communication, and the use of books. The use of language deepens children's understanding of the science with which they are engaged. And as children collect data and represent their work, they may begin to write words, learn new vocabulary, and express themselves using many different media.

- *It provides access to science experiences for all children.* In a good science program, teachers are aware of each child's strengths, interests, needs, and challenges. They provide many entry points into a topic and use many strategies to engage children in science explorations. For example, tabletop blocks allow the child in a wheelchair to experience the challenge of building a structure that is tall and strong. Capitalizing on a child's fascination with knights and kings can encourage him to build castles with strong fortresses. Exploring drops may be fascinating to the child who has no interest in the water table. Many teachers have found that the active and challenging nature of scientific exploration often engages children who have trouble with classroom expectations. And, because science is the exploration of real things and events, children who are learning English can become fully engaged, while demonstrating what they know and can do.

At the core of this book is a belief that the rich experiential environment of a good science program for young children provides opportunities for all children to deepen their understanding of science

ideas. It lays the foundation for meeting a fundamental goal of education, which is expressed in *National Science Education Standards:* "All students, regardless of age, sex, culture or ethnic background, disabilities, aspirations or interest and motivation in science should have the opportunity to attain high levels of scientific literacy" (National Research Council 1996, 20).

The Teacher

Implementing a high-quality early childhood science program builds on what many teachers in early childhood classrooms are already doing as they provide opportunities for children's learning. At the same time, a science program builds on what children are already doing as they play outside, build with blocks, mix paints at the easel, and feed the guinea pig. But as you will see in the chapters that follow, teaching science also means making science the focus of children's work. Creating and maintaining such a focus requires that teachers take on some new tasks and become inquirers about science and about teaching science to young children. How teachers do this depends on the teacher, the children, the science focus, and the larger community. But what they do is the same for all.

- *They choose a focus for inquiry.* The first step is to think about which science ideas or concepts will be the topic for children's inquiry. They may come from a particular interest expressed by a group of children. Perhaps children have shown an interest in the bugs and worms they have found outside, so the topic becomes the needs of living things and how they are met. Or maybe the children have been racing their cars down ramps in the block area, and thus the topic would be how things move. Some new musical instruments in the classroom might suggest a focus on different sounds and what makes them. Or the teacher may choose a topic she feels is important for the children to explore but which they have not come up with themselves. Some questions a teacher might ask as she makes her decision include:

  - Is this topic interesting and engaging to my children?
  - Does the topic draw from and connect to their experience?

- Can the children explore the topic directly over time through hands-on activity?
- What are the basic science concepts for children to think about?
- Are the concepts ones my age group can handle?

- *They prepare themselves to teach the topic.* Many teachers do not have a strong background in science and need to spend time preparing to teach it. Reading books, exploring the Web, and talking with others are all good strategies to acquire some background knowledge and clarify a set of specific goals for a topic. Perhaps most important, however, is working directly with the materials the children will use. By playing, inquiring, and experimenting, teachers can find out what the materials do. They can anticipate some of the things children might do or ask, think of a challenge or focus that might lead to interesting ideas, and be prepared to engage in interesting discussion with children about their work.

- *They create a physical environment that supports inquiry.* Hands-on exploration is at the heart of inquiry. Therefore, teachers need to think about making adequate spaces for this work, selecting materials that will encourage children to explore, and often deciding which materials need to be removed temporarily to encourage in-depth science investigations. Regardless of the focus, teachers might ask themselves the following questions.

  - Is the area large enough for several groups of children to work together? Are there additional places to work on these ideas?
  - What materials will focus children's attention on the science ideas?
  - What materials should I add?
  - What materials can I remove?
  - Are materials such as markers, paper, and clipboards, which children can use to document and represent their work, accessible?
  - What books and pictures can I display to encourage children's science explorations?

- *They plan a schedule that allows time for inquiry.* Children need time to explore a topic in depth. Many explorations can last for

weeks, if not months. Building time into the daily schedule is critical; choice times of forty-five minutes to an hour allow children to explore new concepts and ideas more deeply. A regular discussion time after choice time or at the end of the day helps children share experiences and their ideas. Teachers might look at their schedules and ask:

- Is the choice/activity time long enough for children's explorations?
- Do I have enough whole-group time to discuss what children are doing and thinking?
- Can my class devote several weeks or more on this topic? If so, how can I arrange my classroom schedule?

- *They foster children's questioning.* Children raise many questions as they engage with science exploration. As teachers listen to children's questions they need to ask themselves:

  - Can this question be explored directly? If so, can I provide the support and materials children need to continue?
  - Can this question be rephrased so that it can be explored directly? (For example, "Why doesn't the water come out of the baster?" can be rephrased as "How do you think we can get the water to come out of the baster?")
  - Does this question need to be answered by using resources, such as a book, the Web, or an expert? If so, what resource would be best?
  - Is this question for discussion only?

  Even if it is not possible to follow up on every question and every idea, teachers can use a variety of strategies to let children know their ideas are valued and respected. For example, teachers can save questions on charts, discuss interesting ideas, and where possible help individual children follow up on a new idea or question.

- *They encourage children's work and deepen their understanding.* Teachers need to encourage children to pursue their ideas and questions through various means. They may spend time with children to show how much the children's work is valued. They may add

materials to support children's work and suggest ways to collaborate with others. But teachers also need to go further, encouraging and challenging children to think about their experiences. They need to ask about what happened, why children think it happened, and what they might do next. They need to discuss predictions of what might happen and what theories they have about the particular phenomenon/materials.

Strategies teachers can use to deepen children's understanding include the following:

- *Engage children in conversation as they work.* Using words to describe their observations and ideas can help children think more deeply about their work. Sometimes children talk with one another quite spontaneously. Other times, teachers engage with them when children are ready to talk. Observing carefully is the first step in deciding whether or not to interact. If children are working intently, they may not want or need to be interrupted. Observation also provides the teacher with insights about what question or challenge a child might be working on and guides her in how to engage. Is it how to build a high tower or keep the dinosaur from escaping? Might it be how to create a drinking

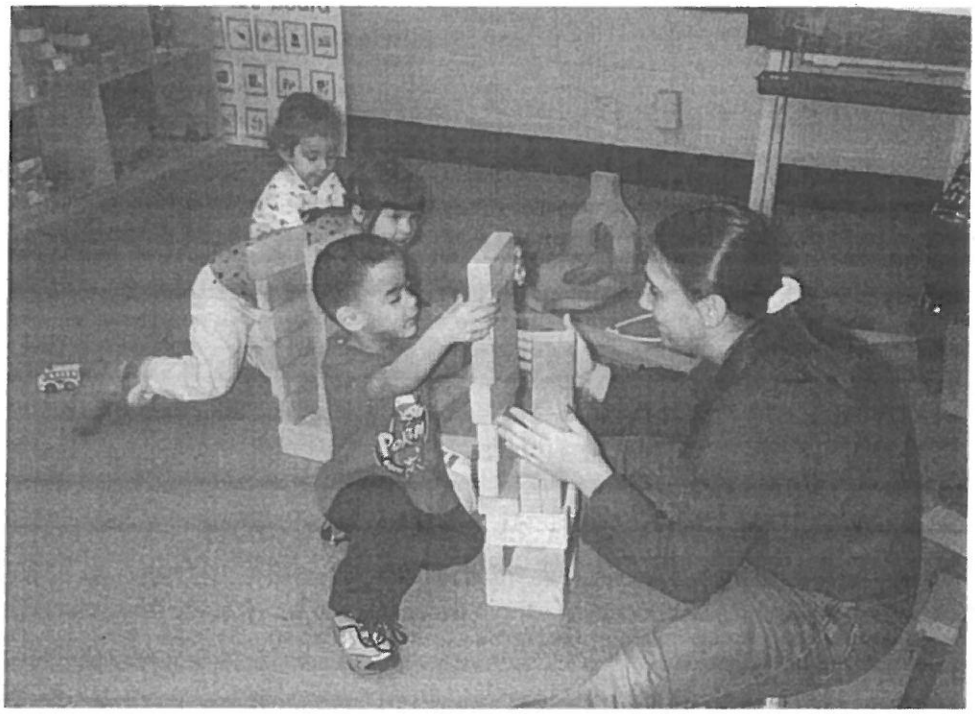

Figure 1–2
A Teacher Supporting Children's Building Explorations

fountain or figure out how the worm eats? Descriptive questions are good to start with: "Can you tell me what you have done?" "What was hard about this work?" Other kinds of questions and new materials challenge children to go further: "Could you use these smaller blocks to make your tower even taller? What is important to keep your tower from falling down?" "The dinosaur is strong. What could you do to make the wall stronger?" "How do you know that the worm eats dirt? How could we find out if it likes other things?"

- *Lead group discussions.* Small- and whole-group science talks where children discuss their experiences and their thinking lead children to think in new and deeper ways about science. If teachers take brief notes as children work, they will have many starting points for these discussions. Children's representations, photographs, documentation panels, and the materials themselves can also deepen the discussion. "Alonzo, tell us about how you made the walls for your dinosaur house very strong." "Alicia, can you explain this picture you made of your building? How many blocks did you use for the tower part?" "Mira, show us how you made the shadow that looked like a frog." As children share their work, teachers also help them make connections between what they have been doing, what others have been doing, and what they already know. "What materials do we need to make a home for our worms? When we were outside, what did we find out they need?" "What was something a lot of you did to make your ball go down the ramp faster?"

- *Encourage children to document and represent their work.* When children document and/or represent their work, they think about their experiences in new ways. Drawing a picture in his naturalist's notebook of a worm will often prompt a child to observe more closely and highlight details. The challenge of painting flowing water may enhance a child's sense of the continuity of the flow of water. Encouraging children to represent involves making materials, such as clipboards, different papers, and collage materials, accessible as children explore. It also means working closely with children, prompting them to look again, to be sure of the color they are using, to count the blocks in the tall tower once more. And it means celebrating what gets done.

- *Document what is happening.* Documenting the science work in the classroom—using words, video, photographs, and children's work—can help children see what happens over time and revisit an event that happens very quickly. The plant gets bigger and bigger; the caterpillar changes into a butterfly. Pictures of children's work over time can also make the process of inquiry visible, such as showing the steps in making a musical instrument or in constructing a system of tubes and funnels to empty the water table into the sink. This documentation then provides a focus for conversations among children, and among children and adults. Making a documentation panel that tells a story with pictures and words is a particular way to give children a chance to see the "story" of their work laid out for them.

- *They observe and assess individual children and the group.* Ongoing observation and assessment is a critical part of teaching science in the early childhood classroom. Teachers need to know about children's experiences, the play they invent, and what interests them and what does not. They also need to try to understand the possible meanings behind their questions, the theories they are working on, and how they communicate their ideas.

  To do this, teachers must become observers and recorders of what is happening as children explore. They may take notes on individual children or groups. They may keep checklists of who has worked where, take pictures, make documentation panels, and keep samples of children's work. While taking the time to observe can be a challenge with all of the day-to-day demands, the data teachers collect is invaluable in a number of ways. Data can help teachers make decisions about the curriculum, what the group will do next, and the types of adaptations needed for individual children. The data can also serve as a springboard for talking with caretakers and staff about the progress of individual children and the purpose and value of the children's science experiences.

As they think about observing and assessing children, teachers might ask:

- Do I have a clear set of goals and expectations for science?
- Do I have a plan so that my assessment is systematic?

- What different assessment strategies will I use?
- How will I keep records of children's experiences and what they are thinking and learning?

Summing Up

Characteristics of a high-quality science program:

- It builds on children's prior experiences, backgrounds, and early theories.
- It draws on children's curiosity and encourages children to pursue their own questions and develop their own ideas.
- It engages children in in-depth exploration of a topic over time in a carefully prepared environment.
- It encourages children to reflect on, represent, and document their experiences and share and discuss their ideas with others.
- It is embedded in children's daily work and play and is integrated with other domains.
- It provides access to science experiences for all children.

The tasks teachers do:

- They choose a focus for inquiry.
- They prepare themselves to teach a topic.
- They create a physical environment that supports inquiry.
- They plan a schedule that allows time for inquiry.
- They foster children's questioning.
- They encourage children's work and deepen their understanding.
- They observe and assess individual children and the group.

PART TWO

The Science Content

Part Two of this book is about the "what" of the early childhood science program. Because doing and learning about inquiry are critical content areas of science, we start with a description of inquiry. The chapters that follow focus on areas of science, or subject matter, that can provide the most meaningful experiences for children ages three to five. We describe a set of core ideas in life, physical, and earth and space sciences that young children can explore and how these ideas can become central to classroom work.

The particular ideas of life science, physical science, and earth and space science have been selected because all are intrinsically interesting to many children and likely to spark their curiosity. They are about concepts that young children can explore directly as they make sense of the world around them and everyday events in their lives. Moreover, current educational research suggests they are within the grasp of children ages three through five. And finally, they correspond to the concepts and ideas of science detailed in *National Science Education Standards* (National Research Council 1996) and *Benchmarks for Science Literacy* (American

CHAPTER 2

Inquiry in the Early Childhood Classroom

Science inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

—National Research Council 1996, 23

Skills of Inquiry

It is not surprising that many have called children "natural scientists." Young children are curious and intent on making sense of their physical and social environment. Enthusiastic explorers of materials, organisms, and events, they bring to their work and play a sense of wonder and a natural desire to inquire. But curiosity alone is not enough for children to develop skills and promote their understanding. For children to develop the skills of scientific inquiry, adult guidance is essential. Teachers can foster such inquiry by building on children's spontaneous exploration and gradually guiding them to become more focused and systematic in their observations and investigations.

Developing children's inquiry skills is a fundamental goal of an early childhood science program. Children need many opportunities to develop and use these skills. But these skills should not be taught in

isolation from interesting topics and ideas and children's ongoing play. Rather, children need to develop their abilities to use inquiry in the context of their experiences with interesting materials and meaningful science ideas. Some specific skills, such as using a magnifier or measuring an object, may require direct instruction. Other skills, such as sorting and categorizing, may also be reinforced or practiced using games or simple activities. But mostly, children will use these skills in a context in which they matter.

There are many different skills that make up scientific inquiry. They include children's ability to:

- raise questions about objects and events around them
- explore objects, materials, and events by acting upon them and noticing what happens
- make careful observation of objects, organisms, and events using all of their senses
- describe, compare, sort, classify, and order in terms of observable characteristics and properties
- use a variety of simple tools to extend their observations (e.g., hand lenses, measuring tools, eyedroppers, a balance)
- engage in simple investigations including making predictions, gathering and interpreting data, recognizing simple patterns, and drawing conclusions
- record observations, explanations, and ideas through multiple forms of representation including drawings, simple graphs, writing, and movement
- work collaboratively with others
- share and discuss ideas and listen to new perspectives

It can be helpful to think about children's inquiry in the classroom as a process that often proceeds through several stages. In each stage, certain inquiry skills are emphasized. The framework for Young Children's Inquiry (see Figure 2–1) suggests that the stages follow one another. To some extent they do, but as the many arrows suggest, the process of inquiry is not linear; children, just as scientists do, will move back and forth and around as they explore.

In the first stage, children notice and wonder as they freely explore materials with little direct guidance. As children explore, many will ask a lot of questions. Others may not put these questions into words, but will act on them. The child who carefully chooses a block and places it on her tower is "asking" something about how to make tall or strong towers. As work continues, some children may be struck by a particular

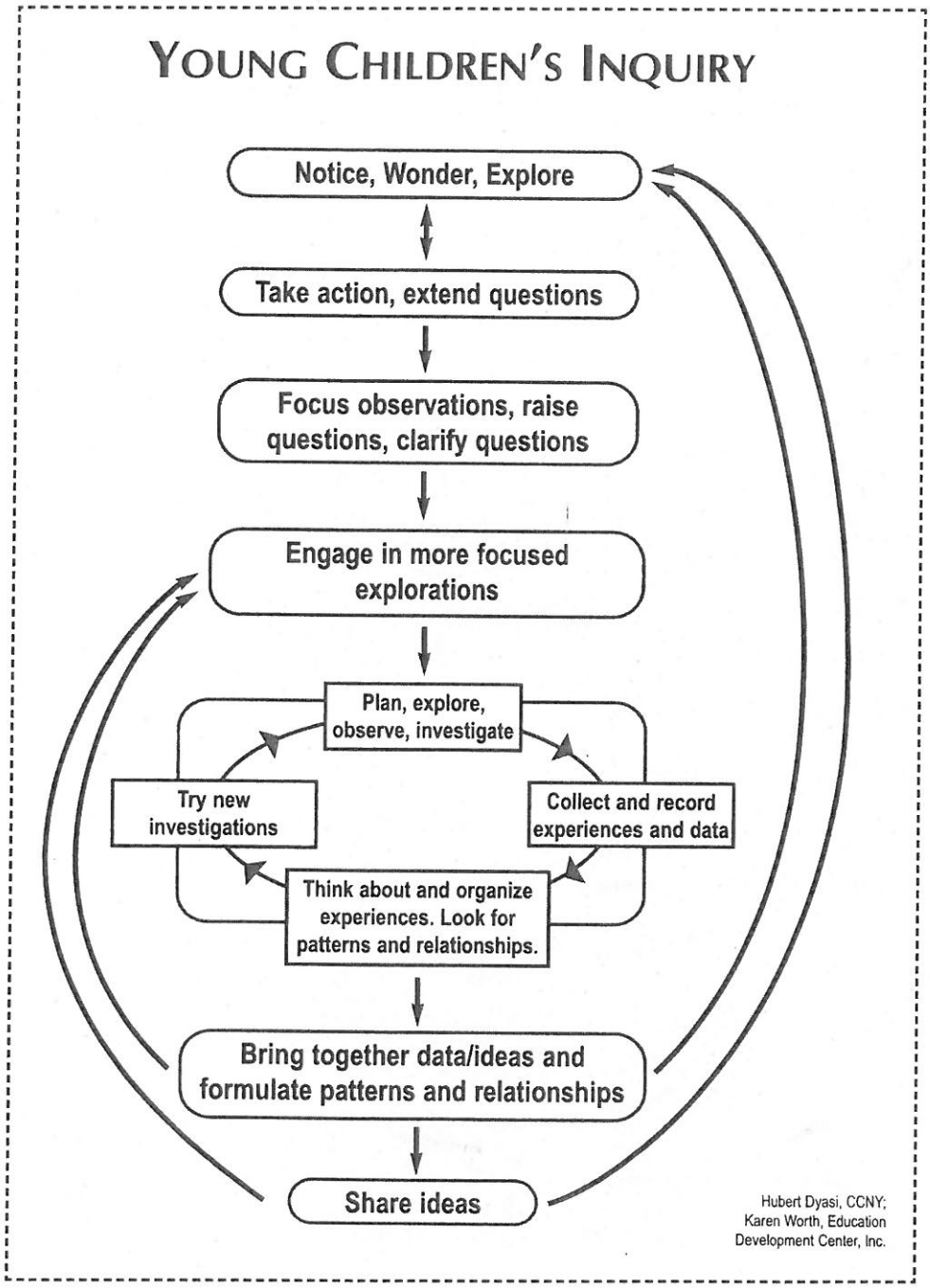

Figure 2–1

idea or question, such as "How high can we make our building before it falls?" Rather than answering children's questions directly, teachers can provide the encouragement and support that children need to follow up.

Children often need adult guidance to move to the second stage, where they focus their observations and raise questions that can be investigated. "Where do the worms come from?" is not one they can explore directly, but "What are the kinds of places in our yard the worms seem to want to be?" can be pursued. Similarly, "Why does the water go down?" demands an explanation, whereas "What are ways I can get the water to go from this container to that one?" provides a springboard for an investigation.

As children explore and investigate in more focused explorations, they are likely to use many of the skills of inquiry. In the classroom stories, there are many examples of how young children plan, explore, observe, and investigate; collect and record data; represent their ideas; think about and organize experiences; look for patterns and relation-

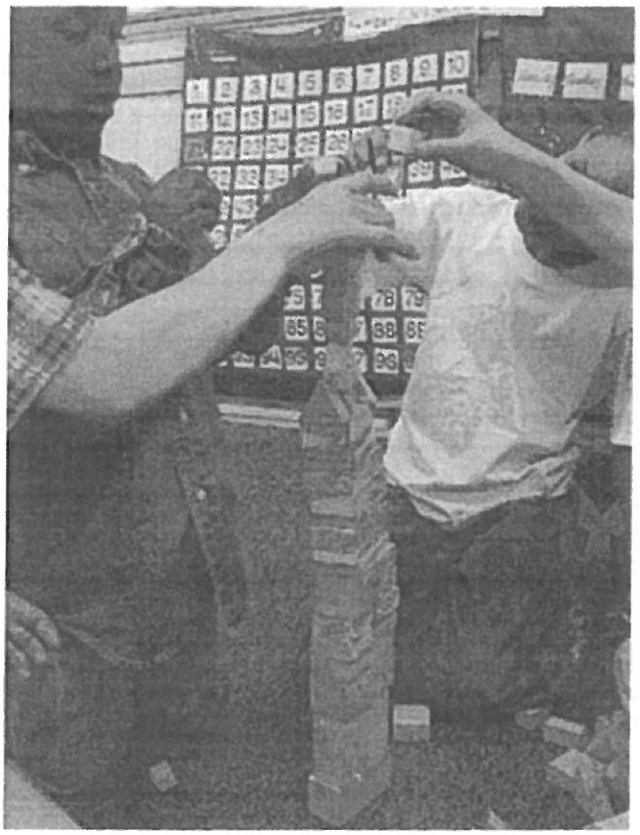

Figure 2–2 *"How high can we make our building before it falls?"*

ships; and try new investigations. Notice that the process is cyclical. Children may explore a question for a long time, and their explorations may lead to new questions and new investigations. For example, observing snails may prompt an exploration of how they move and how they eat.

New ideas in science are built on the experiences and ideas of others. In the final stage of this framework, teachers bring children to share and discuss their conclusions and formulate ideas and theories.

Attitudes of Inquiry

Doing science builds children's inquiry skills; it also fosters a set of attitudes that are important to science and other areas as well. Scientific inquiry is not a dry process or method. Instead, true scientific inquiry is imbued with excitement, creativity, and wonder—fostering children's appreciation of the world they live in, both its beauty and its complexities. At the same time, it encourages children to take risks and pursue new challenges.

Perhaps the most important attitude to maintain is curiosity. Teachers can build on and nurture children's curiosity by making the classroom studies interesting and responsive to their questions. It also is important to encourage questioning that takes children more deeply into their explorations. Connected to curiosity is the willingness to try something out and keep at it. Children often need help as they pursue their questions or new challenges, but by not jumping in too soon, teachers can encourage children to work through their frustrations and feel the satisfaction of accomplishment.

Critical to science is a respect for evidence. Teachers and children should frequently ask questions such as "Why do you think so?" "What did you do?" and "What did you observe?" Records of data and representations of work should be part of sharing as often as possible. A debate about results, such as whose truck went the farthest, should be resolved by doing it again.

And science is a collaborative endeavor. Scientists often work in groups; similarly, group work is the norm in the classroom stories. Constructing new ideas is also a collaborative effort. Carefully guided discussions of work done, new ideas, and differences can help children

develop an appreciation of the work of others and a willingness to discuss and debate findings.

The classroom stories included in the following chapters are filled with examples of children inquiring and developing their abilities to explore a question or event or object. They also illustrate the many strategies that teachers can use to support and facilitate the work children are doing.

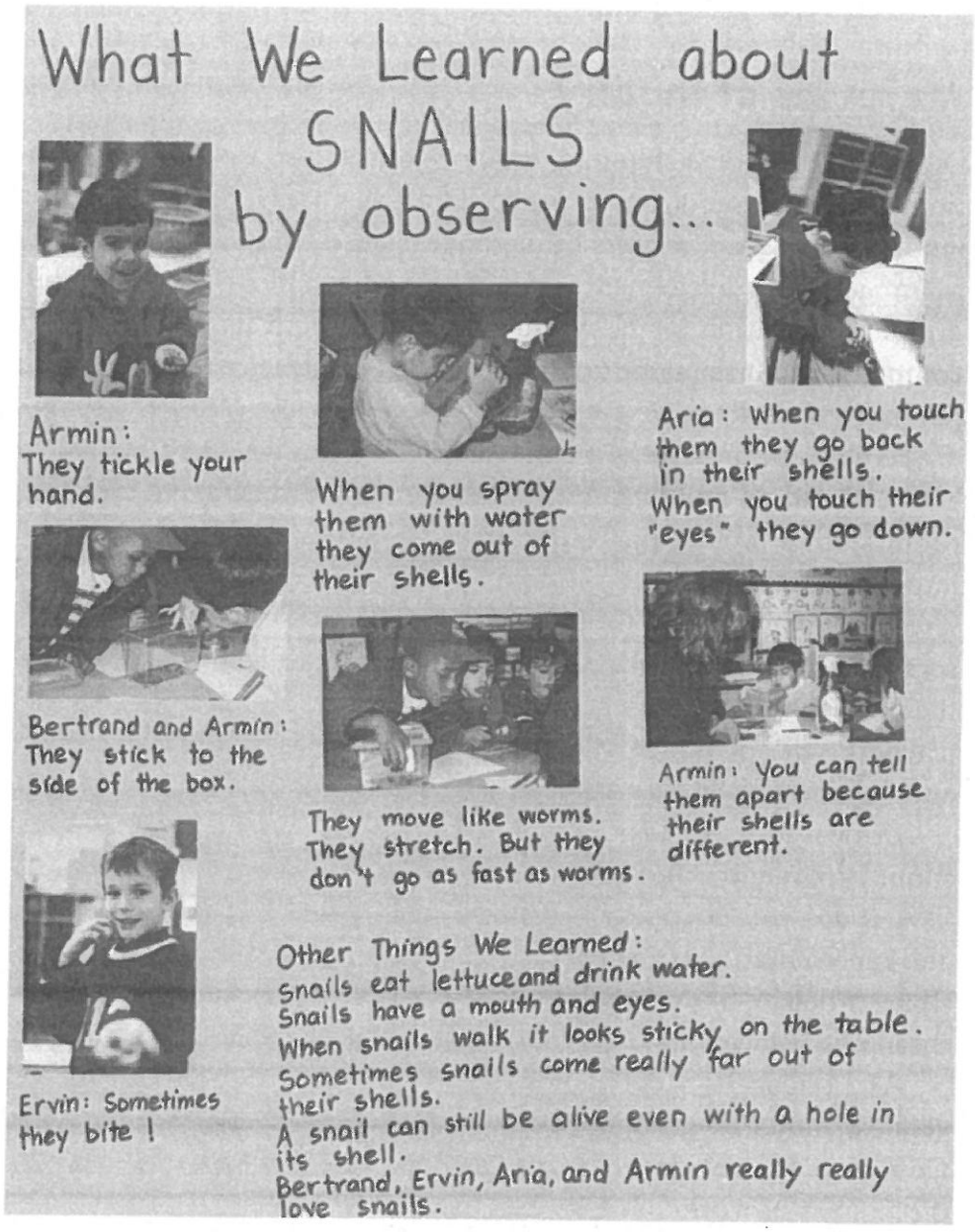

Figure 2–3 *A Documentation Panel That a Teacher Made After Her Class of Three- to Five-Year-Old Children Studied Snails for Several Weeks*

A Word About Design Technology

Although this book is about science teaching and learning, many aspects of technology teaching and learning are closely connected to what children do when they do science.

The *National Science Education Standards* distinguishes science and technology as follows: "The central distinguishing characteristic between science and technology is a difference in goal: the goal of science is to understand the natural world, and the goal of technology is to make modifications in the world to meet human needs" (National Research Council 1996, 24). The process of design technology is much like that of science inquiry. Young children might well be called "natural designers." Their work often includes questions such as "How does this work?" "How can I make this go farther?" "How can I build this higher?" Their play is full of inventions, designs, and construction.

Distinguishing between science and technology, or labeling children's work as "technology," is unnecessary and inappropriate at this age. But teachers can encourage young children to think about their work from the perspective of design technology as well as from the perspective of science inquiry. They can support children's ideas whether the children want to make a container for their rock collection, a telescope to look at the sky, or a portable home for a living critter. By providing materials and serving as a sounding board and guide, teachers can encourage young children to follow through on their ideas while challenging them to think about how things work, what materials work best, problems that arise, and alternate solutions they might explore.

CHAPTER 3

Life Science in the Early Childhood Classroom

Young children are fascinated by the living things they encounter around them. Life science for young children is about maintaining this fascination through the close and often systematic observation of plants and animals, including themselves. It is about guiding children to begin to think about living things—what they look like, how they live, and how they change. That is, the life science program in the early childhood classroom focuses both on the characteristics of an organism and how it lives in its natural environment outside of the classroom. At the same time, it encourages children to treat all things and their environments with care and respect.

Doing Inquiry

Children's study of the living world around them is very much like the work of naturalists. Naturalists identify and describe the plants and animals they find. They observe and record the lives of different organisms and their relationships with one another and with the surrounding environment. This kind of inquiry has a strong basis in observation and recording. As children engage in life science, they use their senses, magnifiers, measuring tools, and notepads. They measure, count, make observational drawings, and even begin to map what they have seen where. As children share their observations and think about what they have seen, they start to sort and categorize, clas-

sify, look for patterns, and raise questions about the living things they have come to know.

Children's study of living things takes time. Watching a plant grow and change takes days and weeks, not minutes or hours. Observing and reflecting on the life cycle of an organism may take even longer, and seeing the changes that happen from season to season can be a yearlong study. Given young children's focus on the present, it is a challenge to make some of these changes truly visible to them. But their own documentation and recording, along with teachers' documentation and ongoing classroom discussion, can provide a bridge from week to week and even from month to month.

CHAPTER 4

Physical Science in the Early Childhood Classroom

Physical science for young children involves direct exploration of objects, materials, and events of the nonliving world that surround children in their everyday lives. The focus of their explorations ranges from structures made of many kinds of materials, to things that move, to water and other liquids, to shadows and light, and to sounds. Physicists and advanced learners connect these phenomena by major theories (e.g., the particulate nature of matter), laws (e.g., Newton's laws of thermodynamics), and abstract concepts (e.g., energy). But for young children, the phenomena are quite discrete and interesting and challenging to explore. The theories, laws, and abstract concepts are best left to later schooling.

Physical science often is neglected in the early childhood classroom. Teachers, unsure of themselves, often view it as too complex for them and their children. In reality, children's exploration of objects, materials, and events goes on all the time, and physical science can become the focus of a great deal of their activity.

Doing Inquiry

Inquiry in physical science is very active. As opposed to living things, nonliving objects and materials can be acted upon. Children can manipulate them in different ways and observe what happens. They can repeat what they have done to see if the same thing happens each time. They can do simple experiments and investigations and collect data,

draw their own conclusions, ask new questions, predict, and theorize. In a classroom with carefully selected materials and the time and space to use them, children can pursue their ideas in quite independent ways in many contexts. They can use the phenomena and materials as part of their dramatic play and their games, as well as investigate what the materials can or cannot do. Physical science activity frequently involves making things and, thus, incorporates some of the skills of design technology. Children figure out how to build ramps for their rolling things, construct very tall towers, or create a flow of water from the water table to a bucket.

As in other sciences, children's inquiry in physical science also involves documentation and representation of their work, although the emphasis is less on observational drawing and more on recording important elements such as how the funnel was connected to a tube. Many of their explorations can lead to measurement, counting, and graphing. How long is the ramp? How far will a ball roll? How much water can fit in the container? How many blocks were used to make the tallest building? Children can draw and make models of what they have constructed, whether a water system with funnels and tubes or a drum that makes very low sounds. But representation also poses challenges in physical sciences. Because the focus is often on action, recording observations such as the flow of water or a ball rolling down a ramp can be difficult. Alternative media, such as photographs, video, and audiotape, can be powerful tools to record such events.

An exciting topic generates a lot of curiosity, and in a well-designed environment, children will pursue some of their questions and try out ideas. Physical science provides many opportunities for children to try things over and over again. Designing a ramp off of which cars don't fall can be a challenge, seeing how far a ball will roll down a ramp may need to be done more than once to be sure the measurement is right, and getting water into a baster can require serious effort. With teacher support, experiences such as these can help children develop patience, care, and persistence when things don't work as they want them to.

Physical science is also a vehicle for fostering children's understanding of the role of sharing, debate, and evidence. For example, when one child says her shadow puppet got bigger when she moved it closer to the screen and another says it got smaller, the teacher can encourage discussion. She can also emphasize that only through doing it again—returning to the evidence—can the children figure out what really happens.

CHAPTER 5

Earth and Space Science in the Early Childhood Classroom

In many ways earth and space science is the most complex of the sciences. To understand the structure of the earth and its history, climate, and meteorology, the solar system, and the universe requires understanding of many of the concepts of life and physical sciences. In addition, studying the ideas of earth and space science means thinking about long time scales, unseen forces, and faraway places. These complicated ideas including plate tectonics, the rock and water cycles, evolution, and the origins of the universe certainly do not belong in the early childhood curriculum.

However, children do come into direct contact with many aspects of earth and space science that they can explore and ponder. Wherever they live, there are earth materials to explore such as rocks, sand, and soil. Water is everywhere in streams, rivers, lakes, and oceans. Rain falls; puddles come and go; things get washed away. Young children experience the changes related to night and day, weather, and the seasons. And they can see the sun and the moon moving across the sky. Because of these daily experiences and interactions, earth and space science has a place in the early childhood classroom.

Doing Inquiry

The nature of inquiry in earth and space science depends a great deal on the topic. A study of the weather, the changing shape of the moon, or the movement of the sun across the sky requires systematic observation

and recording of data. The daily weather chart, a familiar activity in early childhood classrooms, is a good example of systematic recording, and even young children can look for patterns in the data and changes over time.

A study of rocks requires close observation, comparison, and categorization, as does examination of different kinds of sand and soil. A closer look at water in the environment may lead to direct investigation of what happens when water is poured into a sand table or a little rivulet dams up on the playground.

Just as with life science, engaging in earth science can foster the beginnings of important attitudes and dispositions. As children become familiar with their environment and observe the changes taking place, they are likely to take notice and develop an appreciation for the world around them and their role in caring for it.