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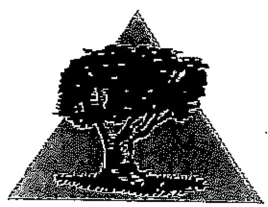
CHAPTER

2

A Constructivist Curriculum Model for Science



In this first-grade classroom there is lots of activity and children are involved in various learning centers. At one table are numerous wheels of different sizes and shapes made of play dough that the children made yesterday. One of them, Sarah, checks on the wheels she made, confirming that they have hardened. She takes her wheels and sits down at a table with a selection of straws and cardboard cartons of different sizes. After sorting through the cartons, she selects a small one and announces, "I'm going to make a funny car!" Sarah pokes straws through the holes in the cartons and makes two axles, then selects two round wheels for the front and two square ones for the back. As she moves the car around the edge of the table, she puts her fingers lightly on the back square wheels as they slide along the table surface.

Sarah stops her car abruptly and begins to smile. She takes off the two rear wheels and, after searching quickly through her pile of wheels, selects two egg-shaped ones and puts them on the rear axles. Now she rolls her car along the table and then on the floor, laughing and calling to the other children as it bumps along.

This activity is science education from a constructivist perspective. Why? Because it is providing children with a developmentally appropriate opportunity to engage in experimentation with the physical world. Sarah is self-directed, bringing her own ideas about movement to an activity that lends itself to many different types of experimentation. This experimentation is done in a context that both allows for and encourages social interaction; it lets children explore their ideas individually or cooperatively. These elements of the activity—self-direction and choice, social interaction, and active manipulation of materials—are congruent with the developmental needs and capabilities of the young child.

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

▲ The Curriculum Model

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

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

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

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

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

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

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

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

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

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

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

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

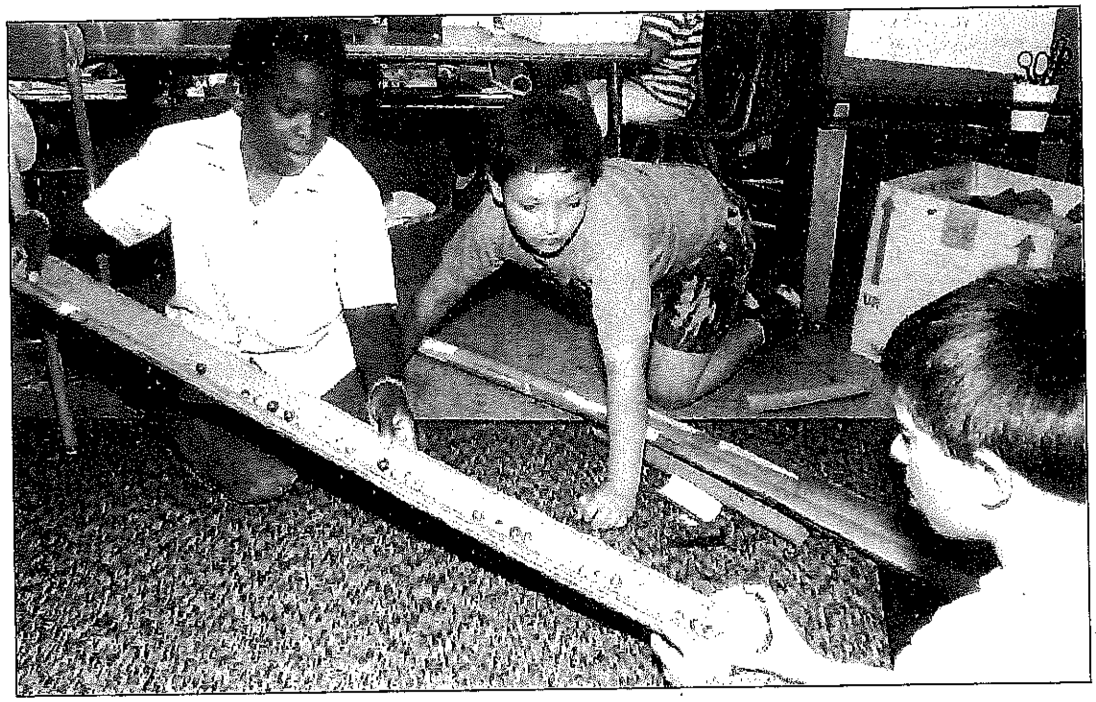
Questions to Generate Experimentation

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

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

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

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



"How can we make it move?" reflects these children's experimentation with inclines and rolling objects.

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

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

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

"How can we make it change?" is the prevailing question of these children's experimentation with tissue paper, glue, and water.

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

How This Curriculum Model Is Different

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

As an example of a traditional theme approach as contrasted with the constructivist approach, take the theme "dinosaurs" for a group of 4- to 5-year-old children. Activities planned for one or two weeks would be designed around that topic. For example, pictures of dinosaurs would be displayed

Being both attentive and gentle with the insect she has discovered is part of the curricular focus "How does it fit?"

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

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

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

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

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

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

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

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

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

Where Do Ideas Come From?

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

What Sorts of Questions Are Children Asking?

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

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

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

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

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