Entries from a Staff Developer's Journal . . .

Helping Teachers Develop as Facilitators of Three- to Five-Year-Olds' Science Inquiry

Robin Friedrichs Moriarty

Rarely do we see three-, four-, or five-year-olds engaged in a science inquiry for months at a time, especially in classroom settings. Rarer still are materials that will support teachers as they learn to identify and deepen children's science understandings in the form of science inquiry. The National Science Foundation is helping make quality science inquiry in preschools, child care centers, and Head Start programs more common by supporting a curriculum development project at the Education Development Center (EDC) in Newton, Massachusetts, a nonprofit research and development institution.

EDC is writing three teacher guides, each with accompanying professional development materials, to help teachers of three-, four-, and five-year-olds identify science-rich questions embedded in their children's play and use those questions to engage their children in age-appropriate science inquiry. Two of the guides, "Exploring Water with Young Children" and "Building Structures with Young Children," focus on physical sciences, and the third, "Discovering Nature with Young Children," focuses on life sciences. Each guide describes ways teachers can prepare for and facilitate an inquiry that can last for eight weeks or longer.

For a month and a half, I supported three Head Start teacher teams as they used the "Exploring Water" materials for the first time. After each of our weekly two-hour sessions, I wrote in a journal and reflected on our work.

The journal discoveries

I knew from the start that I wanted to help teachers develop the confidence and the mechanical skills they need to facilitate a science inquiry over time. My journal entries describe afternoons spent studying the "Plan for Teacher to Follow" sections of the "Exploring Water" materials, rehearsing what teachers might do and say at each stage of the exploration.

But as I reread my journal entries, I saw something much more important. By connecting the basic skills they were learning to the reasons why those skills are key to their role as facilitators of inquiry, I helped teachers improve their ability to apply their new skills to future inquiries—inquiries that could be built around their children's unique interests and science-based questions, inquiries that would unfold without requiring the support of a teacher's guide. In short, as teachers incorporated the following three key principles into their practice, they developed the capacity to apply their evolving skills to new inquiries.

1. Teachers need a basic understanding of science, which involves both the understanding of science inquiry as a dynamic process and a familiarity with the science concepts they will help children explore. Therefore, before "Exploring Water" describes ways

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Photos courtesy of the author.

teachers can begin a science inquiry using questions that three-, four-, and five-year-olds typically wonder about, it leads teacher teams through an abbreviated science inquiry of their own, using the same water materials their children will be using later. This way, teachers feel prepared to act as guides to children, highlighting interesting possibilities and asking key questions as they focus children's thinking on the properties of water.

2. Children need access to thoughtfully selected materials that provide them with opportunities to work with and observe science phenomena. For example, when children have repeated opportunities to explore water with various-sized containers, eyedroppers, turkey basters, pumps, clear tubing, connectors, and funnels, they confront many of water's properties.

3. Reflection is an important part of the science inquiry process. Teachers need to provide various opportunities for children to revisit, represent, discuss, and demonstrate the experiences they have with these specially selected materials. The reflecting that children do on their explorations—for example, at the water table—not only helps children articulate and refine their theories about water flow but also gives teachers the information they need to focus the inquiry in ways that will help children examine their unique ideas about water flow more closely.

Selected journal entries

The following excerpts from my journal as a technical assistant illustrate the ways six Head Start teachers gained important understandings about these key principles as they learned to use "Exploring Water."

Excerpts from week one

Clarissa's question seemed like a good place to start: "I'm already doing science in my classroom. How is your approach different?"

"What does science look like in your classroom?" I wondered aloud. For the next half hour, we talked openly about our beliefs and values as they relate to science education for children from three to five years old. It felt good to get our biases out in the open. I heard about science tables, collections of pinecones, and units on the rain forest, and was handed a couple of well-loved science activity books.

Then it was my turn to describe my image of science for three- to five-year-olds, which is hard simply because inquiry is so dynamic. "For me, science inquiry begins with children's explorable questions," I explained. "When children ask, 'How can I get this water to move through these tubes?' we can guide them in an exploration to find out. But when they ask, 'Why does it rain?' we can't actively help them to explore. Why does it rain? is an intriguing question. It invites children to suggest explanations like 'Because the storm clouds come.' It can be fun to talk with children about their explanations for phenomena like rain and to find out more about their underlying ideas; you can also help them make observations, like noticing whether it really does rain every time storm clouds come. But the question of why it rains does not offer children opportunities to plan, conduct, and analyze a hands-on investigation."

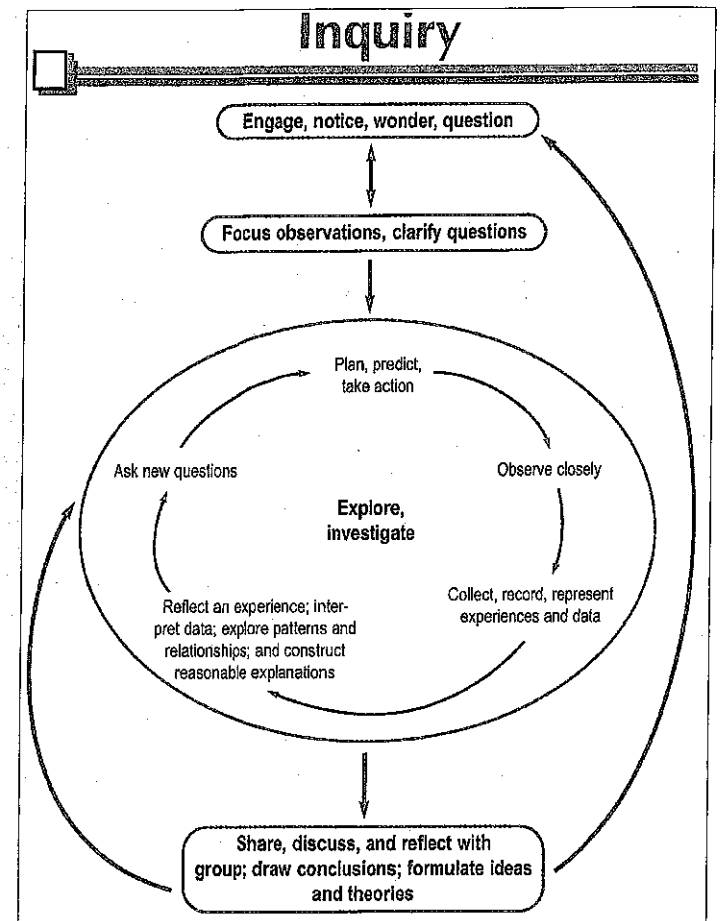
Clarissa asked, "But if I don't understand the science of water flow, how can I help my children understand it?" We headed directly to the water tables! I always enjoy watching teachers explore water with clear tubing, turkey basters, funnels, pumps, and containers of different sizes and shapes, and today was no exception. When I positioned a piece of plastic-covered wire shelving down the middle of the water tables, they became especially intrigued and generated plenty of their own challenges.

Lucy and Clarissa worked to get water to flow over the shelving. Rose and Madeline attached funnels to each end of the shelf and found a way to direct water from one to the other. They named it a potion machine.

After we cleaned up, I charted the responses to my next science-focused question: What did you just notice about water flow? The responses included the following:

- water flows down;
- water will move up and down in a U-shaped tube if you move the sides up and down;
- pumps can make water flow faster; and
- bubbles of air sometimes get in the way of flowing water.

I summarized what I wanted the teachers to take away from this session: "Your children's understanding of water flow—that water usually flows down unless it is being pumped or squirted—will begin to develop as they openly explore different kinds of containers, tubing, and pumps with water, just the way your understanding did!"



Karen Worth, Education Development Center, Inc. (Adapted from joint work with Hubert Dyasi, City College of New York.)

Excerpts from week two

One week later, the teachers were still excited about having played with the water table materials! I'm relieved; I think it would be tough to move ahead if they were not excited. Today, I pulled out the inquiry diagram (see "Inquiry" at right), and we related last week's experiences at the water table to the graphic. (Each of the science explorations professional development packages includes this graphic of inquiry. It serves as a meta-cognitive tool that is best introduced after teachers explored the materials. In this way they can reflect on their own learning.)

One teacher described her experiences:

> At first I just wanted to pour water into every available object in the table! Then I focused on one of the wider tubes: I filled it, emptied it, filled it halfway and shaped it like a **U**, watched the water rise and fall as I moved the sides of the **U** up and down . . . now I see that I was moving from "wondering/exploring" to "taking action/extending" questions.

Yes! They saw the connection! But I needed to make it explicit: "And by engaging in those inquiry processes, you deepened your understanding of water flow!" It was time to move on. "I'm going to help you deepen your understanding of water flow even more!"

We returned to the water tables, but this time I took a more directive role. I wanted to move their inquiry into a more focused phase, so I challenged them to move water from the full table to the empty one—without carrying it! They connected tubes and funnels and pumped water into the funnel to push it through connected tubes and into the empty table. They were very proud!

As we reflected on their work, Sam connected these focused explorations to the inquiry diagram on the wall and to concepts of water flow written on a second chart. Clarissa wondered aloud, "What would happen if the full water table had no legs, and we had to move the water up and into the empty water table?" "Let's try it!" We cycled back into the inquiry! After referring to the inquiry diagram, we got to work.

Excerpts from week three

We'd experienced some open and focused exploration of water flow as adults, but what about bringing water exploration to three-, four-, and five-year-olds? The power of the environment cannot be underestimated, and most teachers enjoy reorganizing their

classrooms and bringing in new materials, so this session turned out to be engaging.

"Having two water tables and other tubs of water around the classroom and outdoors says a lot about the importance of water exploration! And the water play materials are so inviting. I loved the clear tubing and the turkey basters."

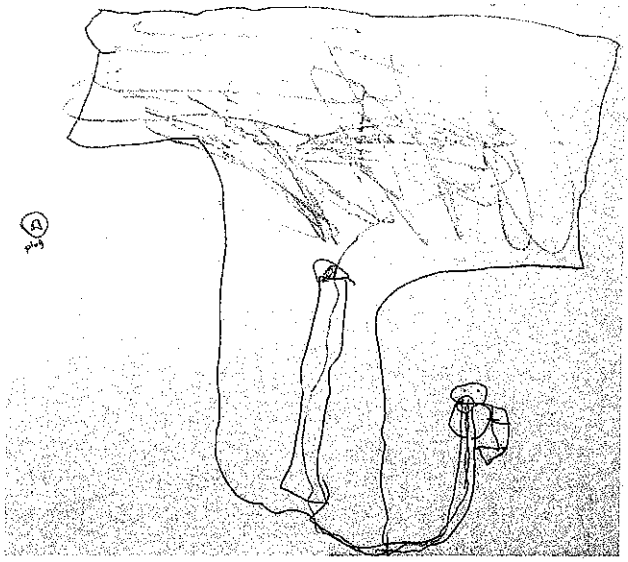
Maxine wondered why we had not included dolls or boats in the water tables. "My children love both." We stopped to remind ourselves which science concept we were helping children develop at this point in the inquiry: water flow. Boats, we decided, would help bring the concepts of sink and float to the fore, but dolls? Nina stated it so perfectly: "Well, they're fun to wash, and they lend themselves to very early water play experiences, but they don't seem to add to a focused look at water flow."

"What about this?" I pulled out a couple of different-sized clear plastic cups that had a couple of holes punched in their sides. "What might these help children notice about water flow? Play with them and find out!"

Some of their discoveries included the following:

- I can make water squirt sideways without a turkey baster or a pump;
- streams of water shoot farther when the cups are full;
- the streams eventually turn into dribbles, and then they stop.

I couldn't help but state the obvious: "If I had given you dolls to wash instead of cups with holes to explore, you wouldn't have experienced these fascinating phenomena just now."



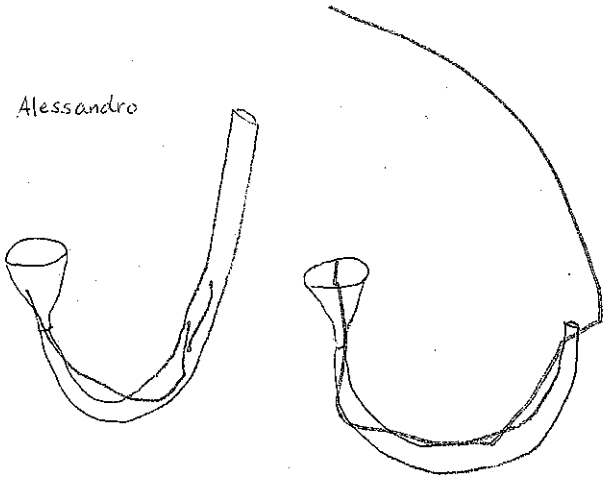
Daire's drawing

Excerpts from week four

I worried that these teachers were going to think science inquiry with young children ends with a rich environment and time to pursue explorable questions. I wanted them to understand the important roles representation and reflection have in science inquiry. I struggled with how to help the teachers realize three-, four-, and five-year-olds' potential for reflection and processing. But using the overhead to share Daire's and Alessandro's drawings did just that.

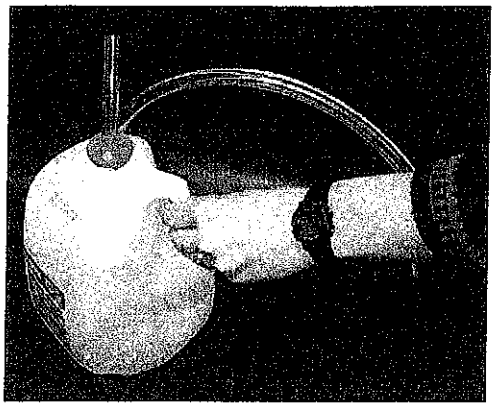
"How can I get my children to create drawings like that!?" was the immediate reaction. We took the next half hour to discuss the mechanics of incorporating children's representational drawing into the classroom culture: expectations, materials, and procedures. But I didn't want to stop there. The next step was to practice analyzing representational drawings with two purposes in mind: to reflect on what they say about children's science understanding and to see how they suggest next steps for the inquiry.

First, we studied Daire's response to exploring water with these materials, which he expressed through his drawing of himself blowing into the longer tube. I asked



Alessandro's drawing

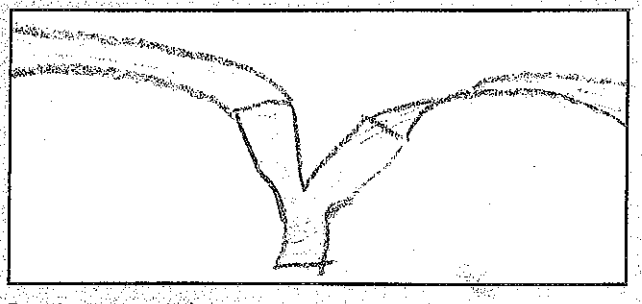
the teachers to consider what the drawing told them about his understanding of water flow.



They concluded that Daire's drawing represents the experience he had making water spurt up and out of the shorter tube by blowing into the longer one. "Do you think he's developing an understanding of force's effects on water flow by noticing the way he can move water with his breath?" I asked. "Yes!" they declared. Next steps for him, they suggested, might include exploring water with different kinds of hand pumps.

The group decided Alessandro's blue marks on his teacher's black-line drawings represented the observations he made exploring water in a clear tube connected to a funnel. The drawing on the left, Clarissa suggested, represents his observation of water resting evenly, on the horizontal, and in the drawing on the right, what happened to the water when he raised the funnel. "Perhaps his observations will help him develop an understanding of gravity's effect on water flow," I suggested. "I think so!" Clarissa responded. Suggested next steps for Alessandro included adding **T** and **Y** connectors to his exploration of water in clear tubing.

Next, we practiced analyzing a third representational drawing by a child named Deon. Deon, I explained, used clear tubing attached with a **Y** connector to explore water flow, just the way we had. His representational drawing raised a question. The group agreed that it represents his observation of two water flows combining into one, but Rose and Carol wondered whether it also assumes the water will stop flowing when it gets to the bottom of the open-ended **Y** connector. Clarissa suggested that someone ask Deon to show what happened when the water he drew flowed into the **Y** connector. Her suggestion gave me the opportunity I was looking for to stress the effect children's representation has on deepening science inquiry: First, I explained, it gives children an opportunity to revisit their explorations, and second, it presents them with repeated opportunities to reflect on their work and the work of their peers throughout the inquiry.



Deon's representation

I suspect we will use our last session to focus quite a bit on strategies they can use to facilitate science-focused conversations with children, whether they be initiated by a piece of representation, a book, a demonstration, or a photograph. There are so many ways to incorporate reflection into science inquiry!

Postscript

I ran into Clarissa today. She is so excited! Some of her children are fascinated with her overhead projector. The other day, she observed a group of four covering the top of the projector with pattern blocks. When they turned the projector on, they were surprised to notice that their colorful pattern wasn't shining on the wall!

Clarissa decided these children have questions about light and shadows, so she borrowed a light table and explored the way different materials looked on it. She also made her own shadow puppets and went on shadow walks in- and outdoors. I asked her what concepts she plans to keep at the center of the inquiry, and she explained that she hopes to help children think about shadows: how they're made, how different materials respond to being lit up from behind or from the front. She is already using two of the key principles to help her develop this inquiry: She has got a basic understanding of the science concepts at the core of the inquiry, and she has collected some intriguing materials to help children explore those concepts.

Clarissa has invited me to meet with her next week so we can brainstorm ways she might help her children represent and share their exploration of light, shadows, and different materials. She has remembered the importance of helping children reflect! But reflection is also key to developing teacher practice; I've decided to make her a blank "Light and Shadows Inquiry Journal" so I can give it to her when we meet.