Dialogue on Early Childhood Science, Mathematics, and Technology Education

First Experiences in Science, Mathematics, and Technology

Science Assessment in Early Childhood Programs

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The momentum toward reform of science education brings pressures on schools and teachers to evaluate or otherwise account for children's progress in science. During an earlier era of neglect of science education, not much attention was paid to assessment and evaluation, but currently there is widespread interest at all levels of the educational system. This interest can bring with it a certain rush to judgment, but it also brings an opportunity to explore assessment alternatives that are fundamentally different from conventional evaluation methods.

Assessment can be defined as the process of identifying, collecting, and analyzing the records of learning in order to make informed judgments about students. Especially in early childhood, this process should support teachers' inquiry into children's learning more than identify discrete strengths and weaknesses. We know that learning takes time, young children need the chance to explore and make connections, and learning is social. Yet this very complexity of learning makes it difficult to see the "science" in children's activities. What does young children's science look like? How do you know it when you see it? Given this context, a first purpose of assessment in early childhood should be to enhance teachers' capacities to observe, document, and understand learning. Opportunities for thoughtful examination of children's learning may not be a routine part of the professional life of many teachers, but new approaches to assessment could provide occasions for such reflection.

General Purposes of Assessment in Early Childhood

Educational assessments serve a variety of purposes and yield different kinds of results. The term *assessment* itself carries multiple meanings. Often, assessments are equated with testing. Statewide "assessment programs" of science are, in essence, statewide "testing programs." Sometimes the term suggests a more diagnostic function, as in the identification of children with special needs. At times, assessment invokes a wide array of procedures drawing upon various kinds of information, for example, classroom assessments of mathematics and early literacy that include the use of student work samples and portfolios.

A recent statement of principles and recommendations for early childhood assessment prepared by an advisory group for the National Education Goals Panel accentuates the importance of differentiating purposes of assessment (Shepard et al. 1997). (Distinctions of purpose are also prominent in the *National Science Education Standards* [National Research Council 1996].) As the panel's report indicates, the purposes determine the content of the assessment; the methods of collecting evidence; and the nature of the possible consequences for individual students, teachers, schools, or programs. In the past, serious misuse of tests and other instruments in early childhood has often stemmed from confusion of purpose. Instruments designed for one purpose, such as identification, may be completely inappropriate as instruments to measure the success of a program. With respect to early childhood education, four purposes provide the framework for the report's recommendations:

- assessments to support students' learning and development as part of instruction,
- assessments for the identification of special needs,
- assessments for evaluating programs and monitoring trends, and
- assessments for high-stakes accountability.

In this paper, we focus upon the first assessment purpose—to inform instruction and support learning. We start from the premise that the foremost function of classroom assessment in the early years is to enhance teachers' powers of observation and understanding of children's learning. We stress this function for two reasons: the rapid and variable nature of children's learning and the interactive nature of teaching. The classroom science envisioned in *Benchmarks for Science Literacy* (American Association for the Advancement of Science 1993) calls for interactive instruction, which presumes that teachers can respond to young children's interests, background knowledge, and emerging skills. Whether the program is defined by science themes, units, or kits, the role of the teacher as observer and shaper of the classroom program is critical. Science instruction, which promotes children's inquiry and problem solving, must be guided by cues in the children's behaviors and language as well as by curriculum expectations.

Guiding Principles of Preschool Assessment

Multiple Forms and Sources of Evidence

Learning in early childhood is rapid, episodic, and marked by enormous variability. Even the most carefully designed assessment instrument cannot, by itself, capture the complexity of a child's understanding. Instead, evaluation of learning should be based on multiple forms of evidence from many sources. In active science programs, children make choices, voice opinions, and perform various investigations. In such settings, children might demonstrate their interests, understandings, and emerging skills through their conversations; their questions; their actions; and the work they produce, such as constructions, drawings, or writings. It is this sort of evidence that teachers can rely upon when evaluating whether an activity is meaningful and whether children are learning. The children's ongoing behaviors and their work are the stuff of teachers' everyday observations, records, and evaluations. In the case of science education, the richer the instructional environment, the broader the potential range of evidence for assessing learning (Bredekamp and Rosegrant 1995).

Evidence Collected Over Time

Since young children's thinking reflects both developmental and experiential factors, teachers need to have a good sense of the appropriate instructional pace, allowing time for exploration and accommodation of new ideas. Children need time to revisit interesting phenomena; they need opportunities to ask the same question over and over again, perhaps in new or slightly different ways. Important ideas develop gradually—over days, months, and years—and are seldom the result of a single lesson or demonstration. Moreover, the development of thought is not neatly sequential, but rather marked by detours and explorations. Given this pattern of learning, indicators need to be collected on a regularly scheduled basis. For example, some portfolio assessment programs require that documents be collected at three or four specified periods of the year. Whatever the data collection method, the goal is to obtain records that reflect the child's developmental progress (Bredekamp and Rosegrant 1995).

Evidence Highlighting What the Individual Knows

The evidence collected in early childhood assessments should go beyond the "deficit" model and highlight what children know. Teachers need to understand that children's "misconceptions" about natural phenomena are not necessarily unproductive; they may reflect keen observations and efforts to make sense of the world. For the teacher, this assessment requires an attitude of listening, of asking questions in an open way, and of attending to unanticipated answers. This stance toward assessment is exemplified when teachers collect information about children's interests and prior experiences as a step in planning instruction. For example, as an introduction to a unit on paper, a group of kindergarten teachers made experience charts from the things that children said were "made out of paper," "not made out of paper," or "not sure." The chart was revisited over the course of the unit.

Evidence of the Collective Knowledge of Groups of Learners

Young children's science learning is inherently social. A teacher with whom we have worked remarked, "It's the many little conversations among children that really count for something" in promoting their ideas and observations. As an example, she described how a child discovered that by getting under the aquarium stand and looking through the glass bottom, one could witness a whole new dimension to the life of the fish tank, such as watching the sea worms tunneling in the sand. This experience caught on among the children, and, over the course of weeks, it promoted much talk and exchange of observations.

Although individual learning is typically the focus of classroom assessments, teachers need to be responsive to the patterns of interest and knowledge within the group. Documents reflecting the social dimension abound in young children's classrooms, such as displays of drawings, records of class discussions, and observations of group projects. Exploration into the understandings of a community of learners can provide insight into the prior knowledge and experiences that students bring to learning environments.

Documentation as an Approach to Assessment

For a number of years, we have been meeting with teachers in elementary and preschool settings to explore classroom strategies for documenting children's science learning. Documentation is an approach to assessment that attempts to build directly upon evidence from teachers' everyday experiences of observing and listening to children and collecting samples of their work. As an approach, these methods are more open-ended than tests or checklists, yet more structured and systematic than incidental recordkeeping.

Children's Talk

In our work to date, we have found that children's talk and language about natural phenomena is of particular interest to teachers and serves as a useful starting point. In the early grades, children's conversations and discussions constitute perhaps the single richest source of evidence to teachers concerning the substance of their students' ideas. However, in contrast to drawings, writings, and constructions, discussions leave behind no artifacts or documents for the teacher to review or consider. Children's talk is a facet of the teaching experience that tends to remain unrecorded and, hence, not ordinarily accessible to review.

Guidelines for Documenting Science Discussions

In early education classrooms, most discussions and conversations among the children occur spontaneously and informally. However, there are also occasions when teachers bring the children together to share ideas and to talk about some activity. With some attention on the teacher's part, these occasions can become opportunities for investigating children's thinking.

The following guidelines were formulated with teachers who participated in a study of children's science learning. These guidelines were intended to facilitate the sort of discussions that are sustained by child-initiated questions and ideas and that allow children some control over the direction or drift of their remarks. In such settings, interactions among children may well bring out lines of thinking that are not so evident in individual interviews or group lessons, when children must deal more directly with the adult's agenda.

1. Discussions begin with open-ended questions, such as:

   "What are some things made of paper?"
   "Where have you seen shadows?"
   "What do you know about water?"
   "What have you noticed lately about our caterpillars?"

2. Children shape the agenda of the discussion.

The teacher sets the stage for conversation but does not dominate it. Children are allowed time and space to formulate ideas in their own terms and to pursue aspects of a topic that are of greatest interest to them. In general, teachers refrain from correcting or modifying children's comments.

3. Participation by all children is encouraged.

   Teachers steer the discussion in a way that encourages comments from each child at some point. "Going around the circle" is one strategy. A discussion that involves most of the group will bring out evidence of the variety of interests among children; it will also highlight issues or questions that are commonly shared.

4. Records are made of each child's statements.

   There are different ways of making a written record of the discussions. The fullest records can be made via tape recording or observer notes. Other records can take the form of "experience charts," lists, etc. Full transcripts are not needed, but an effort should be made to capture the key terms in any child's statement.

Kindergarten Class Discussion: The Fish

The following discussion of a "dead" fish illustrates how the teacher provides structure for a conversation while allowing the children to shape the agenda. The result is that the matter of a fish's scales—the intended topic—becomes subsidiary to larger questions of whether the fish is dead and how to make that determination. In this particular example, the discussion led directly to a classroom investigation.

Note: Donna Erickson, a Philadelphia kindergarten teacher, made this transcript.

Fish Observation

While I was reading The Rainbow Fish to the class, a child asked what "scales" were. A few days later I bought a fish at the supermarket and brought it to the class. Sitting in a circle, I showed the class how to feel the scales and invited them to tell us anything else that they noticed about the fish. Their discussion follows.

Darryl: "You got to scrape the scales off and then cook it."
Kate: "Was the other fish bigger in the book?" (Class thought the book fish was bigger.)
Blair: "I had a fish that die."
Jennifer: "Fish will swim in the water."
Sarah: "I love to eat fish."
Ashley R.: "I notice that he's dead."
Alina: "It makes me remember trout fishing with my grandfather."
Derek: "At my old school we fed fish in a pond."
Liam: "The eye reminds me of jelly."

Frank: “It reminds me of my alive fish. This one’s alive. No. It’s dead. I see the blood (around the eye).”
Earl: “It’s wet. I can feel its scales. I think it’s alive.”
John: “I think it’s dead.”
Teacher: “Why?”
John: “I don’t know.”
Mickey: “It smells bad. I think it’s dead because I see blood.”
Richard: “It’s dead.”
Teacher: “Why do you think so?”
Richard: “Because fishes always die?”
Shelby: “I like fish. I think it’s alive.”
Teacher: “Why do you think it’s alive?”
Donovan: “I like fish.”
Ashley H.: “It feels like my cousin’s fish. It’s dead ‘cause it ain’t movin’.”
Danielle: “It’s not movin’. It’s dead.”
Darryl: Jumps up and yells. “No! Fishes swim in the water. You gotta put it in water!”
(Many students agree.)
Zoe: “It’s dead.”

I got a plastic shoebox and filled it with water and put the fish in and set it before the children. I heard someone say, “It’s sleepin’,” and many agreed. I told the class that I’d put the fish on the table and they could keep their eyes on it. Kids went over throughout the day to check it out. Once there were screams of “It’s moving! It’s moving!” but then someone said, “No it’s not. You just bumped the table and the water’s movin’.” By the end of the day when I asked the class about the fish, they all agreed that it was dead because it never moved.

Lessons From Early Literacy Assessment

Over the past three decades, there have been major changes in assessment of early literacy, with some lessons for primary science. Where once *readiness* was narrowly measured, newer methods reflect a broader conception of literacy and recognize that children’s steps toward reading and writing entail much more than alphabet recognition. These changes not only reflect theoretical advances but also extensive teacher participation in the observation of young children’s efforts to make sense of print. Portfolios and other methods have played an important part in strengthening the teacher’s capacities for inquiry and the teacher’s contributions to new models of assessment. These methods have also demonstrated how assessments can build upon practice and how they need not interrupt teaching but can be embedded within instruction (Jones and Chittenden 1995).

Interest in science assessments brings the opportunity to explore methods that require a central role for early childhood science teachers. There are of course some critical differences between language arts and science instruction. For teachers, recognizing the science in children’s behavior may well be more problematic than observing children’s development as readers and writers, in part because of the teachers’ own limitations of content knowledge. In addition, the boundaries of the child’s development as a “scientist” are less clear. Children’s ways of figuring out how the world works are not constrained by science lessons but cut across the curriculum areas. These points argue for greater involvement of teachers in the documentation and analysis of children’s science learning, both for professional development and for the design of appropriate assessments.

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