Embedded Assessment

This method not only helps teachers to evaluate student progress but also guides instruction.

By Gerald William Foster and William Anton Heiting

Teaching and assessment are mirror images of one another. Assessment guides instruction, and instruction guides assessment. In fact, it is the assessment of children's behaviors, actions, and ideas that drives instruction. As Duckworth (1987) says, "A good listener or a good understander of explanations is aware that his or her first interpretation of what is being said may not be the right one and he or she keeps making guesses about what other interpretations are possible" (p. 22). This ability to "read" children and to make instructional decisions based upon what children are saying is the essence of assessment. Assessment should be a continuous process involving listening, observing, and asking questions to promote intellectual growth.

Setting the Standard

The traditional emphasis on memorization in science education assessment has created lingering false assumptions about the purpose of assessment, implying that assessment should bring closure to learning and focus on specific science terminology rather than on processes or broad general ideas. Children's responses tended to be ignored unless they were the "right" answers, and evaluating those answers was an endeavor separate from the actual teaching process.

Teaching consisted of giving directions, guiding students in completing investigations with predetermined outcomes, and administering a written test.

Recent state mandates and the arrival of national standards in science education are forcing teachers to re-examine assessment methods and to develop items that appropriately assess not only what science ideas children are learning, but also their ability to use science processes. Mandates also are requiring that assessments be reliable and valid. In other words, recent trends in science education are forcing educators to abandon traditional testing and to adopt hands-on assessment activities with scoring rubrics to validate learning.

A Change in Time

Unfortunately, many of the templates created with an emphasis on hands-on assessment are operating under the old assumption that teaching and assessment are separate (Foster and Heiting, 1993). An alternative to this situation would be to embed assessment within everyday science activities so that it is an ongoing process rather than a culminating activity given at a specified time (Silversten,
Figure 1. These indicators were devised as a way to guide preservice and inservice teachers in assessing the basic science process skills.

1993). Embedded assessment helps teachers to understand what children are learning, and it also helps to guide instruction. In fact, instruction becomes a mode of inquiry. Teachers engage in the science of observing children while children are engaged in the science of observing objects.

During hands-on science, children manipulate objects and learn from these actions. They observe cause-and-effect relationships, and they collect data to create new understandings. Likewise, during hands-on science, teachers observe and interact with children as if the children were objects of study (Foster and Pellens, 1989). By observing children’s interactions with objects, asking and answering questions, and giving suggestions, teachers collect data about what science processes children are using and what they are learning from the activity. Student actions and responses can be recorded while they are working, using varied techniques such as checklists and anecdotal remarks. Such data can be used to change instruction as well as to learn about the children. Thus, during hands-on science, both teachers and students should be involved in inquiry, although they will be operating at two different levels.

Inquiry begins with asking questions. To begin the assessment process, two questions must be asked:

- What science processes and skills are children using during specific hands-on activities?
- What concepts or ideas are children learning from these science experiences?

Beginning with questions such as these rather than with curriculum goals inspires teachers to assess genuinely what children are learning and doing. Stated curriculum goals often are vague and have little purpose. Consider the following goal, commonly found in electricity units: “Devise experiments to determine when a bulb-and-battery system lights.” Exactly what does this objective mean to the teacher? How many experiments? How do you “determine” when the system lights? How well-designed should the experiments be? Obviously, this goal is open to a variety of interpretations. The focus is on product rather than process and doesn’t provide any insight as to what the children have learned.

On the other hand, questions that...
emphasize processes and learning help to focus attention on what the children are doing in their science investigations. A teacher might ask children to describe relationships through questions that begin "What if...?", "Why...?" and "How...?". The ability to state relationships gives evidence of a child's own understanding of reality in contrast to verbalizing content from textbooks and other sources.

Using specific science activity goals to guide instruction may actually direct attention away from relevant assessment information. A stated goal for an activity might read: "Describe how a simple battery-and-bulb electrical circuit and switch work." What does it mean to "describe"? What sort of descriptions would be acceptable? Do children describe electrical circuits according to their own actions or according to electrical current theories? If the answer is "electrical current theories," then hands-on investigations are irrelevant to the goal, because children cannot observe how electrical currents work, only their results. A more appropriate question would ask, for example, "What do you observe about the light bulb when two batteries are used?"

Limiting the purpose of assessment to determining whether goals have been met creates a filter as to what information is collected. It is as though a scientist were to look only for expected experimental outcomes, ignoring all other data. Making predictions about what children will do or learn is acceptable, but teachers should be open to the unexpected.

Assessing Learning
What will the data collected through observing, listening, and asking questions tell you about children? From this close interaction with students, you will be able to determine the level of understanding they have about a given concept. For example, children who are learning from hands-on activities will express understanding in terms of organized actions with objects. In other words, they will explain relationships between their actions and the behavior of objects. For example, a child might say, "The magnet still picks up paper clips even..."
though it broke when I dropped it." If children are not learning from the experience, perceptions will override reality. Another indicator of not understanding is whether or not chil-

dren use explanations that could have originated only from other sources. For example, a child who says, "The continents move because they are on plates," is clearly repeating an idea learned from a textbook, videotape, or teacher rather than expressing an idea that the child structured from direct experience.

Finally, when children are able to apply ideas learned from one activity to other activities and experiences, they are clearly demonstrating conceptual understanding. For example, after experimenting with balloons and rubbing them with different materials, a child once said, "So that's what happens to clothes after they've been in the dryer!"

Assessing Processes

In addition to assessing children's ideas, using indicators for science processes can help to distinguish different levels of understanding.

Figures 1 and 2 (see pages 31 and 32) list seven basic and seven complex science processes with definitions and indicators that describe three levels of understanding. The basic science processes, used by children at all age levels, will provide foundations for using complex processes. In general, children will have difficulty using complex processes until they have had experiences using basic processes. For example, the complex process of making inferences requires creating models of explanation based upon interpreting data collected through limited use of the senses. Explanations for such phenomena as electricity and magnetism were created in this manner because they cannot be directly observed.

The indicators help to illustrate how science processes can be assessed. Basic processes, such as classifying, observing, and communicating, are likely to be used automatically by children all the time during hands-on science activities, and teachers may want to know at what level they are being used. On the other hand, processes such as predicting, questioning, using numbers, and measuring will need teacher encouragement. Assessing basic processes can be accomplished by such methods as informally asking "what if" questions. Assessing complex processes requires a variety of informal and formal data-collection methods, since these integrate many of the basic processes.

An Integrated Approach

Integrating teaching and assessment establishes a structure conducive to learning. It puts the focus on both the learning processes and the products of learning. As Shavelson and Baxter (1992) say:

The embedded assessments have several desirable characteristics. They provide almost immediate feedback to teachers on their students' performance, and on how this performance compares with that of students in comparison schools. Moreover, the assessments reinforce hands-on teaching and learning. Nowhere is the symmetry between teaching and assessment more apparent than with embedded assessment" (pp. 24–25).

Mirroring teaching and assessment in terms of scientific inquiry can make learning not only exciting for children but also for teachers who want to know more about their children and to improve the learning environment.

Resources


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