Chapter 8

Assessment and Evaluation

A Guide for Science Instruction

Learning Objectives

After reading Chapter 8, students will be able to

- describe and distinguish between forms of assessment (alternative, authentic, performance, traditional),
- distinguish between assessment and evaluation, including the roles each holds in teaching and learning,
- demonstrate the alignment of instructional objectives with assessment,
- describe the purposes and uses of analytic and holistic rubrics, and
- apply the use of a rubric with assessment.

NSES TEACHING STANDARDS ADDRESSED IN CHAPTER 8

Standard C: Teachers of science engage in ongoing assessment of their teaching and of student learning. In doing this, teachers

- use multiple methods and systematically gather data about student understanding and ability;
- analyze assessment data to guide teaching;
- guide students in self-assessment;
- use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice; and
- use student data, observations of teaching, and interactions with colleagues to report student achievement and opportunities to learn to students, teachers, parents, policy makers, and the general public.

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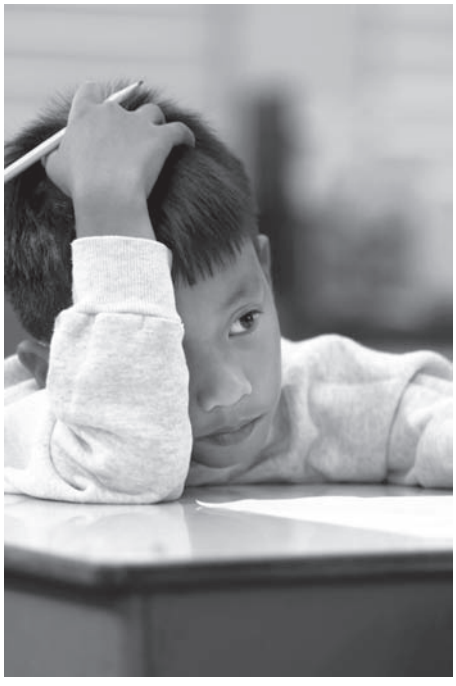


Consider students' reactions when you return their scored work or a test. There may be a range of reactions but most assessments are connected to a student's emotions.

Introduction

Take a moment to think back on your school experiences. Recall your thoughts and emotions when a teacher returned your graded work. Were you excited, unconcerned, or fearful of the results? Whatever the outcome of your assignment, good or bad, it is probable that you saw the grade as a personal and emotional reflection on you. Assessment, evaluations, and grades are connected to the affective domain. This connection often triggers feelings related to self-esteem and the way one views the discipline being graded. In fact, children may form a disposition toward science simply because of the grades they make in the discipline.

Remember, assessments and evaluations are more than red pens, happy faces, gold stars, and grades. So it is important for teachers to consider carefully why, how, when, and what we assess or evaluate because at some point, very early in formal schooling, the impact of assessment and evaluation affects the learner. The following quote by Albert Einstein is one that challenges teachers to really consider "what" we assess or evaluate.

> *"Not everything that counts can be counted and not everything that can be counted counts!"*
>
> —Albert Einstein

How might this relate to your experiences with assessment or evaluation? What examples can you describe to illustrate the quote?

Einstein's quote may well have captured the essence of how important it is for teachers to make clear to students why and how a task for assessment or evaluation "counts." While Einstein's quote reflects "what" counts, Ms. Wilson's narrative in Your Science Classroom: Team Meeting and Planning, portrays a different stance on "how" assessment for learning counts.

YOUR SCIENCE CLASSROOM: Team Meeting and Planning

Ms. Wilson wanted all her students to meet her learning outcome. She announced to her fourth-grade students that if their reports on the electricity (circuits) investigation was accepted, they would receive an A, and if it was not accepted they would receive it back for revisions. After revisions, if it was accepted then they would also receive an A. Now, as you might expect, some children asked what would happen if they still needed further revisions. Ms. Wilson replied that they could redo it until it was accepted. At that

Teaching Standard B: 1 & B: 2

How does this scenario reflect these standards?

time they would receive an "A," because they had met the standards. She said, "Because I wasn't lowering the score for each retry, I worried there would be complaints that I wasn't being fair, but I had none."

Another concern for Ms. Wilson was time. She knew it would take more time to assess multiple submissions but decided to do it anyway. She created the rubric and went over it with the students. The rubric focused on students' demonstrating their knowledge of electrical flow in series and parallel circuits by means of drawing and writing. She waited for the completed projects and found that eleven of the eighteen children achieved the standards. Not great, but at least there were only seven to reassess. When the students' work was returned she said, "I was delighted to see children working and talking with others about ways to make it correct. Mind you, they were not copying—they were talking about what was weak or incorrect and discussing how it should be!" Only two children made revisions a third time. Though it did take more time, there were fewer reviews because only the parts that needed improvement were examined. All students succeeded and were actively focused on learning. At her team meeting she shared what she had done and asked, "Give me some feedback—what do all of you think about using this strategy?"

What are the trade-offs of assessing in this manner for students? What are the trade-offs for teachers? Would you like to be a learner in Ms. Wilson's classroom? Explain.

This short narrative shared by a practicing teacher profiles a teacher who is interested in all children learning science content and achieving success while developing positive dispositions toward science. Her emphasis, like that advocated in the National Science Education Standards (National Research Council [NRC], 1996), has shifted from assessment *of* learning, which creates an image of learning as defined by a grade, to assessment *for* learning, which creates an vision of learning with ongoing assessment used to modify teaching strategies that provide optimal learning opportunities for student success.

Consider your own experiences: Were your assignments focused on assessment *of* learning or assessment *for* learning? We hope the assignments were more in line with assessment *for* learning. In either case, assessment has already played a large role in your school experiences. It will play an even larger role in your career as a teacher. Assessment and evaluation are deeply embedded within the fabric of the educational system and throughout society. After all, don't we all assess ourselves and others from time to time? Of course we do, but in science education, assessment and evaluation are defined more specifically, as you will find in this chapter. At this point, however, it is important to recall that no matter how one assesses, our purpose is to find out what students know and what we can do to continually enhance their opportunities to learn science. In your journey to become an elementary or middle school teacher of science, we encourage you to reflect on issues of assessment by pondering the following: Can any assessment ever completely reflect another person's knowledge or skills? How does a score reflect a learner's knowledge? How many times have you looked at your own scored work and realized that you knew more than the task demonstrated? How do you decide how much is learned? What does an "A" or "B" student look like? Can you tell the difference? Yes, we ask many questions because assessment in any form is an extremely important aspect of teachers' work and a skill you must continually develop and refine. As you read this chapter and carry out the activities in the 5E model, the question

remains: "How do we find out what students know and can do in science to continually enhance their opportunities to learn?" Once we have addressed this question, the next step is recognizing that assessment and instruction are unsurprisingly connected within the instructional setting.

Engage

What Is Assessment? What Is Evaluation?

Quick write: Take a minute and write down your description or definition of assessment. After you complete your ideas on assessment, write down your description or definition of evaluation. Diagrams or drawings will work as well. Keep your descriptions for comparison later as you complete the chapter. The next step is to explore assessment in a classroom activity.

Explore

Assessing Student Work

Your fourth-grade cooperating teacher has asked you to assess Laura Kate's work using the rubric she designed for the activity.

The activity: The letter-writing assessment is embedded within a two- to three-day classroom module during which students explore the circulatory system and health. The assessment is designed to challenge students to write and draw their understanding of the processes and science content knowledge learned during the activities within the structure of writing a letter.

Teacher's Desk Tip: Addressing Diversity in Your Classroom

In this assessment example, be aware that it's important to be inclusive and sensitive to students from nontraditional families.

Directions Given to the Students

You will write a letter to someone who is important to you (parents, grandparents, friend, teacher, or someone else you select). The letter should tell about the science you have been studying and what you have learned or found out. You may include drawings, calculations, diagrams, or tables. You may also include questions you have about the science content or processes you have been learning.

Students were given the rubric. The instructor discussed the rubric and the assessment with the children. The criteria in the rubric included the following (see Table 8.1):

(1) Explain the heart rate or pulse activity.

(2) Use the appropriate vocabulary.

(3) Incorporate three elements of letter writing (see below).

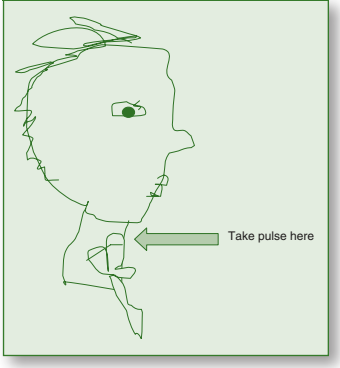
Letter-writing elements include (a) using correct standard English, (b) using correct letter form, (c) expressing opinions, (d) supporting arguments, (e) suggesting alternative procedures or

Table 8.1 Letter Writing Assessment Rubric for Heart Rate

Rubric	Quality			
Criteria	**4**	**3**	**2**	**1**
Understands and explains how to take a heart rate or pulse rate	Clear description of taking pulse rate; no errors in reporting; details and connections made to other learning	Some evidence of taking a pulse rate; some errors in reporting, and some connections to other learning	Description of pulse rate not fully explained, many errors in reporting, few to no connections to other learning	Description of pulse rate unclear, many errors, few details and few to no connections to other learning
Uses appropriate vocabulary	Use of scientific terms (four or more); no errors in term usage	Use of scientific terms (at least three); minor errors in term usage	Use of scientific terms (at least two); major errors in term usage	Use of at least one scientific term; errors in usage

solutions, (f) making writing consistent with the relationship between the writer and the addressee, and (g) expressing feelings about the meaningfulness of the activity. Now examine the letter by Laura Kate (see Table 8.2).

Figure 8.1 Drawing of "How to Take a Pulse Rate"



Laura Kate's Work Sample

On the back of her work, Laura Kate draws a picture of how a person takes a pulse rate (see Figure 8.1).

Now that you have analyzed the work given to you by your cooperating teacher, consider the following questions: What challenges or problems did you have in completing the rubric? What would you do to improve the task or rubric? What did learn about what Laura Kate can do or has learned from the task? Would you consider this an assessment or an evaluation? Explain.

Table 8.2 Laura Kate's Work Sample

Dear Mom,

For homework I have to take your pulse. we learned how to take your Pulse in school. All you have to do is take your two fingers your point & middle fingers and put them below the side of your face (ether side).Then leave them there for a minite and count. The more food that you eat that put's fat on your body is the more the arteries are going to glog up. your arteries are the blood veins and when you put your fingers on your pulse you fill them going in and out. They are pumping blood. When you are finish with doing your pulse three thimes you have to average them. When you average you add all the numbers up. Then the you divide the answer and the numbers that you added you count them up. Well here is an example

23

24

26

3/113

That is how you average. Now here is example of how you do your pulse. on back drawing

Love,

Laura Kate

Explain

Focus Questions

1. What is assessment? What is evaluation?
2. Why is assessment important?
3. What role does assessment play within the classroom, school, and community?
4. What forms can assessment and evaluation take?
5. What types of assessment strategies are appropriate in an inquiry-based classroom?
6. What are the advantages and limitations of various assessments?

Assessment or Evaluation: What's the Difference?

In general, **assessment** is viewed as the act of collecting and interpreting information about students, whereas **evaluation** is passing a judgment (Northwest Regional Educational Laboratories, 1994, 1998). Consider for a moment that a student receives an 81% on a task; that score represents a measure of the student's knowledge for that given task. However, when evaluating the student's work a teacher asks, "Is this good enough to meet the designated criteria?" Decisions about the quality of students' assessments are considered evaluations. Whether the assessment represents a happy face, numerical score, or a letter grade, evaluation is a judgment on the quality of the learning. Assessment and evaluation are often used synonymously and indeed the difference between them is subtle. If you don't make a distinction between the two terms, and many people do not, keep in mind that assessment is an ongoing, systematic process. Both assessment and evaluation should include a variety of forms, both traditional (e.g., multiple-choice tests) and alternative (e.g., student-generated responses).

Assessing and measuring knowledge in any form is never complete nor is it totally objective. For instance, if you create a multiple choice test or develop criteria for a student project, the test items you select or the questions you pose for the project are based on the subjectivity of what you find important for the students to know. So, in this sense objectivity is a myth. However, that doesn't mean that assessments cannot be effective. Effective assessments of learning can be accomplished by collecting assessment data from many sources. Multiple assessments give teachers a more comprehensive understanding of what students know and can do. Finally, effective assessments require that the assessment administered to students align with the learning objectives and instructional approach while recognizing and valuing the different learning styles of the students.

Assessment and Its Role in Supporting Education

Assessment is a predominant feature of education in the United States. It is a mechanism for meeting standards and objectives, and measuring student learning. It takes on a variety of forms, both alternative and traditional, and in some cases the assessment becomes evaluation as seen in state-mandated, standardized testing. Good or bad, make no mistake, test score results affect individuals, programs, schools, and the community. With the reauthorization of the Elementary and Secondary Education Act of 1965, known today as No Child Left

Behind (2002), traditional standardized testing results are paramount to a student's success and are the measures that determine successful schools and the teachers therein. Clearly, it is essential that assessment, whether traditional or alternative, mirror the curriculum and comprehensively measure students' knowledge and skill. Within an inquiry science classroom where children are actively and creatively engaged in problem solving and critical thinking, you will find that alternative and traditional assessments provide useful data on student learning, albeit with different purposes. In preparing students for science in the twenty-first century, we must recognize that mandated testing is primarily based on lower levels of cognition. As the educator Kingman Brewster stated, "To many students of proven intellectual capacity, the prospect of 20 years of competition for nothing worthier than test scores dampens all inspiration." (*New York Times*, January 2, 1991). We must strive to assist students in acquiring the necessary skills of critical thinking for problem solving and use assessments appropriate to accomplish this goal and ignite intellectual inspiration.

Given the impact of legislation through No Child Left Behind (2002), and the accountability issues associated with national standards-based initiatives, it is important to understand the impact of assessment and ultimately evaluation from the perspectives of the various stakeholders (students, teachers, community members, administrators, and departments of education, to name a few). Therefore, we begin with the rationales driving assessment at the local school level that include the following:

- To make sure teachers have met the local or state standards, or both
- To make sure students meet local or state curricular objectives, or both
- To determine whether students have the skills and knowledge needed to proceed
- To make curricular decisions at the school-wide level
- To determine the quality of teaching and schools

External assessment at the state or national level communicates to students, teachers, parents, and the public what the state or nation considers important to teach and learn in school (Bond & Cohen, 1991). This broad public communication does the following:

- Validates what disciplines are important by assessing those disciplines as a part of the school function
- Influences policy to monitor the outcomes of instruction
- Shapes curriculum in both positive and negative ways

With the implementation of No Child Left Behind in 2002, these communications have been clearly demonstrated by the singular emphasis in our schools on reading and mathematics, both of which are highly monitored and tested throughout the year. Science and other disciplines have been marginalized in the elementary curriculum, and in some cases are rarely taught in the K–6 grade levels. In some states science testing in the elementary grades was not part of the No Child Left Behind mandate

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Assessment and Research

- Effective assessment is at the heart of successful decision making (Anderson, 2003).
- Assessment is derived from the Latin *assidere,* "to sit with" meaning to sit with the student. "It is something we do *with* and *for* a student, not something we do *to* them" (Wiggins [1992], cited in Green [1998]).
- "Teachers make somewhere between 800 and 1,500 decisions every day" (Kauchak & Eggen, 2005, p. 55).
- "Most teachers do not see assessment as part of decision making or something that makes them better teachers, but something they have to do to grade students and please parents or administrators" (Arends, 2003).

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Assessment and Communicating With Parents

The lists of words and phrases below are a sample from Shafer's (1997) publication *Writing Effective Report Card Comments* (pp. 42–45). She suggests the avoidance of some terms and the careful use of others when assessing children or communicating with parents can create a more supportive and a less stressful encounter.

Terms to Avoid	Positive Terms	Needs Improvement Terms
unable	thorough	could profit by
can't	caring	has trouble with
won't	excels at	benefits from
always	shows commitment	needs reinforcement in
never	has a good grasp of	shows a need for

between 2002 and 2007. During that time, the message to teachers was that their teaching priority was reading and mathematics. Now with renewed state testing of science in the fifth grade, science is again considered a valued part of the elementary curriculum. Students' science scores on standardized tests clearly influence local school systems' policies; decisions regarding instruction, professional development, and school improvement are made based on the analysis of student data as schools strive to meet annual yearly progress.

National and statewide assessments have become an important process within education. Ultimately for teachers, however, assessment is important in communicating to children and parents ways in which learning can be supported and enhanced for student success in the classroom. Therefore it is important for teachers to ask the question, "How is assessment used to improved instruction?" There are numerous responses to this question but the following are ones that we find teachers cite as the most important. Teachers state that assessment (a) serves to find out students' prior knowledge, (b) clarifies students' conceptual understanding, (c) shapes instructional decisions, (d) assists in placing students in productive learning groups, (e) communicates to students the teacher's expectations, (f) documents student learning, and (g) provides feedback to students and their parents.

In this section we have discussed the differences between assessment and evaluation, uses of assessment at the national and statewide levels, and uses of assessment by teachers to improve instruction. The next section addresses the important connection between classroom assessment and instruction.

Connecting Assessment and Instruction

As you have probably experienced as students yourselves, assessments can range from traditional multiple choice tests to alternative assessments. No matter what form assessment takes, the key to effective assessment is to align the assessment to the teaching objectives and the instructional approach used. In the following narrative, Ms. Lyle, a first-year teacher, shared her experience with assessment when using an inquiry science activity with her fifth-grade students.

Learning objectives can and should be assessed in a variety of ways. When choosing an assessment consider the balance between selecting an assessment that measures what is being taught and what can be learned about the students' knowledge against the time constraints associated with using the assessment. In other words, if you're going to use student interviews, which are time-consuming to develop and conduct, then use them to assess long-term gains of

YOUR SCIENCE CLASSROOM:
Matching Instruction to Assessment

Teaching Standard
C: 4 & C: 5

How does this scenario reflect these standards?

Ms. Lyle was a first-year fifth-grade teacher and a science enthusiast. The next topic in her curriculum was on characteristics of invertebrates. Rather than teach directly from the text, she decided to explore invertebrates in the children's neighborhood, and she was very excited to begin. She planned various activities with insects, arachnids, and worms, activities that included collecting and examining samples of grasshoppers, beetles, spiders, praying mantises, bees, hummingbird moths, cabbage butterflies, and sulphur butterflies. She discussed safety, including handling animals with care and washing hands well after handling them. The children also created a worm habitat while observing and reporting on the behaviors of worms and changes they saw in the compost habitat. The children keep journals with drawings, generated questions (How does a worm poop? How do you know which end is which? What are the rings? How do grasshoppers lay eggs? What do the eggs look like? Who is Polyphemus? How are cocoons and chrysalises different?), participated in grand discussions, read the textbook, and conducted research to learn about the various invertebrates they collected. After two weeks, Ms. Lyle gave the children a multiple-choice test taken from their fifth-grade textbook. Throughout the explorations, Ms. Lyle was excited about all that she observed taking place with her students. They were engaged and learning! She just knew her students would do well on the test. After she scored the tests, she was heartsick. About two thirds of the class made very low scores on the test, and the highest scores were no more than average. She wondered where she'd gone wrong and couldn't understand the discrepancy of what she'd seen them do in the classroom with what they did on the test. So at the next team planning meeting, Ms. Lyle shared her story with her mentor who listened and then asked her what she thought went awry.

What do you think might account for Ms Lyle's students' poor test scores? As a member of Ms. Lyle's team, what feedback and suggestions would you offer Ms. Lyle to alleviate or prevent this problem from happening again?

key concepts or skills. For instance, it is more practical to use interviews as an assessment for students' mastery of key concepts at the end of a unit rather than to use them to assess a few science concepts taught within a lesson. In broad terms, effective assessment strategies do not just happen by luck. Effective assessment involves aligning the instructional approach and the objectives to the task or test to ascertain a comprehensive understanding of what students know balanced against the time it takes to develop, administer, and score it.

Assessments for Inquiry

Recall Ms. Lyle's story. On the one hand, she implemented student-centered inquiry strategies; on the other hand, though, when it came time to assess, she used a traditional multiple-choice assessment that was not tailored to her inquiry strategies and possibly not aligned to her learning objectives, which are not identified in the narrative. Teaching science as inquiry,

by its nature, prompts the teacher to explore alternative ways to find out what students have learned and can do. This often requires assessments that go beyond those traditionally used. What other methods, besides traditional (multiple choice, True/False) assessments may be useful for science inquiry approaches in the classroom? During inquiry lessons students frequently learn through active, hands-on, minds-on activities and traditional tests often do not adequately assess these types of learning activities. For example, when we teach an inquiry-based sound lesson to second graders, we address the National Science Education Standard, "Properties of Objects and Materials," for K–4 grade levels (NRC, 1996, p.106). One learning objective is that students describe how sound is created by vibrations of various materials. A second learning objective is that children build a sound instrument (given a variety of items) and apply their knowledge of sound to change the pitch and volume of their instrument. Traditional tests are valuable for measuring factual knowledge, but here is a case where there is little match between a traditional assessment and the learning objectives. Consider for a moment how a classroom of students studying sound might appear. Imagine the students exploring sound activities in centers located around the room. In the centers, students use straws, balloons, string, cups, tuning forks, combs, and cans to identify characteristics of pitch and volume. Can you envision an assessment for this kind of instruction? Did you consider a task where student match pitch to its definition, or did you consider something else? The instructional objectives and pedagogical approach described in the sound activity are perhaps better suited to an alternative assessment such as the performance-based assessment described below.

Second-Grade Performance Assessment on Sound

Objective 1

Children will be able to demonstrate orally and in a written report that they understand sound is created by vibrations of materials using a self-made sound machine.

Objective 2

Given a variety of items, children will be able to (1) build a sound machine and (2) demonstrate orally and in a written report how to change the pitch and volume using a self-made sound machine.

National Science Education Standards: K–4 Properties of Objects and Materials. Sound is produced by vibrating objects. The pitch of sound can be varied by changing the rate of vibration.

Teacher Preparation

Children will explore sound activities in science centers, hold lively discussion regarding their explorations, and conduct additional activities to answer their questions.

After all the activities are completed, the teacher will ask the children to design and make a sound machine that has variable pitch and volume. A table will be set up with materials for the children to use. Other items for making a sound machine requested by students will be provided if available. They will be given sufficient time to create their machines and write their reports.

Go over the sound rubric to be used on the task with the students (see Table 8.3).

Directions to Students: You will make a sound machine from the available materials on the table. Your machines cannot be identical to any of the sound examples used in your previous activities. Your machine should be original in some manner. Your machine must do the following:

1. Produce sound
2. Demonstrate a change in volume
3. Demonstrate a change in pitch

When you complete your machine, be ready to present and explain how it works to the class.

1. Describe how your machine makes sound.
2. Demonstrate how your machine changes pitch and volume.
3. Complete the report (see below).

Table 8.3 Second-Grade Sound Analytic Rubric

Criteria	2	1	0	Comments
Did I tell how the sound machine works to make sound?	Clearly states how the sound is produced by a vibration of your machine	Not sure, not clear	Didn't state it	
Did I tell what pitch is?	Demonstrates a complete description of pitch (refers to the high/low sounds)	Vague description of pitch	Missed it or forgot it	
Did I show how to change pitch with my machine?	Demonstrates two or more pitch changes with the machine	Discussed some but slipped up on some of it	Missed it or left it out	
Did I tell what volume is?	Demonstrates a complete description of volume (refers to loudness)	Slid over volume	Didn't tell about it	
Did I show how to change volume with my machine?	Discussed and made two or more volume changes with the machine	Discussed in part but was not clear	Skipped it or missed it	

Alternative Forms of Assessment

In the example of inquiry presented, the alternative assessment and rubric are designed to assess students on the instructional objectives in a way that is similar to the way in which they were taught. It doesn't mean that a matching test would not work, but it does mean changing the objectives. The objectives as stated make it clear that the purpose of the activity is to ascertain the learners' knowledge of sound and their ability to apply that knowledge. This assessment makes transparent what they know and what they can do. We refer to assessments seen in the example as an alternative assessment.

MY SOUND MACHINE

Student name: _____

My sound machine is named _____

Draw a picture of your sound machine.

What do you need to do so that your machine will make sound?

How do you change the pitch?

How do you change the volume?

In general, **alternative assessment** is an umbrella term that defines those forms of assessment whereby students generate a response instead of selecting an answer (i.e., multiple choice, true/false, matching). Alternative assessments include any student-generated response seen in essays, short answers, oral presentations, demonstrations, photogalleries, and portfolios. In essence, alternative assessment is a broad term that encompasses both performance and authentic assessment, which are not mutually exclusive.

Performance assessment refers to direct, systematic observations of actual student performances and to the rating of those performances according to preestablished criteria. Some would argue that all assessments are performance assessments. However, we argue that not all alternative assessments are performance assessments. For instance, an essay is an alternative assessment but it is not a direct and systematic observance of a performance. When a performance assessment activity is embedded within a science unit it does not necessarily appear to be an assessment, we refer to this type of assessment as an **embedded assessment**. It may actually appear to be just another inquiry activity that students complete without teacher assistance. Could the sound machine assessment discussed earlier be an embedded performance assessment? Yes, it could, and it looks just like one more activity that is usually given during the middle or at the end of the unit.

Another form of alternative assessment is authentic assessment. **Authentic assessment** focuses on the learner's demonstration of content knowledge and skill in ways that resemble real life as closely as possible. Products of authentic assessment include oral tasks, written tasks, performances, or interviews, to name a few. The following illustrates an authentic assessment used with fifth-grade students.

Fifth-Grade Authentic Performance Assessment

Properties and Changes in Matter

Objective 1: Given a variety of materials, students will identify color change in their scientific report as evidence of chemical change.

Objective 2: Given a variety of materials, students will design a test, conduct the test, and explain in a scientific report which of the antacids tested is best in lowering the pH of stomach acid.

National Science Education Standards 5–8 grade levels

Physical Science

- Properties and changes in matter

  Substances react chemically in characteristic ways

  Scientific inquiry

  Abilities necessary to do scientific inquiry

  Design and conduct a scientific inquiry

  Develop descriptions, explanations, predictions, and models using evidence

  Communicate scientific procedures and explanations

Teacher Preparation

After a series of activities exploring acid–base interactions, pH, and neutralization reactions, students are directed to complete the following task. Provide materials and set up the equipment in an area that is accessible to all students. Go over the directions and safety procedures with the students and discuss using small amounts of substances in the tests. Prior to students beginning the activity go over the rubric with them so they understand how they are being assessed (see Table 8.4).

Safety

Wear safety glasses.

No eating or tasting in science labs.

Report any spills to the teacher immediately.

Table 8.4 Fifth-Grade Properties and Changes in Matter Analytic Rubric

Criteria	3	2	1	Comments
Did I describe what I observed when the chemicals reacted?	Observations were drawn or written with complete details	Observations were drawn or written with moderate details	Observations were drawn or written with few to no details	
Did I explain what happens when an antacid (base) is added to an acid?	Explained in detail the changes that occur (amounts added, color changes)	Explained most of the changes that occur (amounts, color changes)	Explained few of the changes that occur (amounts, color changes)	
Did I describe the test design completely?	Included all of the details in the report	Included most of the details in the report	Included only a few details in the report	

Directions to students

Your dad has been complaining about indigestion and takes an antacid. From the various materials available, your task is to design a test to demonstrate which antacid is best and explain how the antacid works.

Students are given an indicator (radish or red cabbage juice) and pH strips. They also receive a sample of vinegar or lemon juice. Students select two different antacids (crushed to powder) to use in their tests. Other necessary equipment (balances, filter paper, testing trays, tweezers, etc.) will be available for them to use. Students are encouraged to use only very small amounts of materials in their tests. Students write a report using the experiment guidelines that include the necessary components needed to conduct the tests to determine which antacid is best for their dad to use and describe how they know a chemical change occurred.

Students are assessed using a rubric that reflects the learning objectives of the task. As with the second-grade sound example earlier in this chapter, the rubric and report form were discussed in advance with the students. In this example, as you probably recognized, the students were applying their acquired knowledge of chemistry and scientific inquiry in an authentic, real-life application.

Alternative assessments, whether authentic, performance, or both, require products or processes that are often more open-ended than traditional assessment. Therefore, alternative assessments are viewed by some as more subjective than traditional forms because the task can be completed successfully in more than one way. Alternative assessments generally require rubrics that can take considerable time to create and often require several revisions. However, alternative assessments with sophisticated tasks can be useful in examining higher-order thinking and levels of learning that traditional tests cannot examine. In addition, well-developed alternative assessments generally provide opportunities for more authentic, interdisciplinary applications of science concepts than traditional assessments. However, the scoring of alternative assessments, without a doubt, takes much more time and often involves

FIFTH-GRADE SCIENCE EXPERIMENT: CHEMICAL CHANGE

Name:_____

1. What is the question you are trying to answer?

2. Remember to state how we operationally define "best."

3. Did I write my hypotheses?

4. Did I describe the variables?

   Independent

   Dependent

   Constants

5. Did I write the steps used in the experiment?

6. Did I write how I recorded data and observations?

7. Did I write a conclusion and state which hypothesis is accepted?

developing a scoring rubric in advance of the task assignment.

No matter what form of assessment is used, the following guidelines are suggested for creating effective assessment in your classroom (Wiggins, 1992).

- Provide opportunity for the learners to exhibit worthwhile knowledge and skills
- Foster the development of the learners' strengths
- Involve collaborative peer–peer and teacher–student interactions
- Strive for inviting, real-world application contexts
- Aim for "big ideas" or concepts in science
- Include challenges that integrate knowledge across disciplines
- Target the development of a quality product, not a single answer

As a novice, strive to use one or two or these guidelines when developing your assessments. It is difficult for even an experienced teacher to incorporate all of the guidelines into every assessment used. In either case, using the guidelines as a referent can assist teachers in creating effective assessments when selecting, designing and incorporating tasks for their science classroom. Bulletin Board: Alternative Assessment Products offers many examples that are appropriate for use in K–8 science classrooms.

Learning requires communicating with yourself, your peers, and informed others. It requires effort and a meaningful assessment of the effort. In the following sections on portfolios, self-assessment, and science journals, we examine alternative assessments that provide a venue for communicating one's learning.

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Alternative Assessment Products

A letter	Oral presentation
Advertisement	Pamphlet
Animated movie	Survey
Photonarratives	Play
Gallery (art, photographs, etc.)	Skit
Block picture story	Poetry
Chart or concept map	Press conference
Model	Prototype
Collage	Riddle
Comic strip	Science story
Demonstration	News story
Web quest	Slide show
Storyboard	Song
Puzzle	Television program
Journal	Video clip
Diary	Time line
Diorama	Brochures
Editorial essay	Create a rule
Experiment	Science tale
Family tree	Flip book
Game	Graph
Labeled diagram	Interview
Map with legend	Maze
Mobile	Instrument (sound)

Portfolio: Assessment Using Collections of Student Work

The key to assessing student's learning and the success of a science curriculum lies in the methods that assist a teacher and student in measuring progress toward instructional

TECH CONNECT: Online Student Portfolios

Portfolios can be powerful assessment tools and an exciting way for teachers, students, and parents to see the work and progress of the student. To find out more and view examples of portfolios, see Portfolios for Students and Teachers (K–12): TeacherVision.com located at http://www.teachervision.fen.com/assessment/teaching-methods/20153.html.

Read about how to create and use eportfolios for K–8 grade levels at EducationWorld.com located at http://www.educationworld.com/a_tech/tech/tech111.shtml. In addition here are a few sites with tools for creating electronic student portfolios:

Mahara Open Source eportfolios located at www.mahara.org

http://eportfolio.org/

http://docs.moodle.org/20/en/E-portfolio

goals. A large amount of a teacher's time is related to assessing student learning. To make science learning meaningful, it is important to frequently collect both formative and summative data about what children can do. Recall that **formative assessment** occurs during learning process, is often ongoing, and used to guide instruction. In short, formative assessment is assessment *for* learning. **Summative assessment** is assessment to determine whether the instructional objectives have been met. It is assessment *of* learning. Given the current testing climate, it is common in classrooms to see worksheets and tests composed of multiple choice, true/false, or matching items—all of which emphasize low levels of cognitive engagement, whether summative or formative in nature. This approach is entrenched in a history of educational evaluation that views these items as objective, equitable, and easy to score. Despite continued historical trends and the emphasis on standardized testing, talented teachers manage to provide students with a variety of assessment opportunities. In fact, after years of talking and working with creative teachers, we have found that many believe effective assessment should challenge students intellectually, engage them in the task, bring forth what they know and can do, measure student growth over time, and provide learners with authentic, real-world contexts. A portfolio is an effective assessment based on the teachers' criteria. Portfolios are challenging assessment tools that give students the opportunity to showcase their best efforts in a collection of their work.

The use of portfolios to assess students' performance received considerable attention in the mid 1990s along with the science reform initiative, Project 2061 (American Association for the Advancement of Science; AAAS, 1991). Since that time, portfolios permutated into many forms and there is no single design. They do not all look alike, nor should they. There is no formula for designing portfolios. The purpose and design can be determined by the teacher, student, or both. The versatility of the portfolio is considered one of its strengths. In general, portfolios are collections of students' work that are gathered over time to portray the learners' knowledge and skills. A portfolio is a representation of a learner's growth and provides rich opportunities for students to reflect on their own learning.

Just as a scientist decides what evidence is necessary to support a hypothesis, students also can decide what evidences of work represents their knowledge and skills. When they do so, a portfolio becomes a reflective, metagcognitive tool providing them with intellectual independence and autonomy regarding their own learning.

Because portfolios represent a range of work collected over time, both teacher and student gain insights into the individual's learning patterns and those experiences that influence the learning, not to mention the power they hold in demonstrating the learner's progress to parents. Despite the variations found in portfolios that are usually negotiated

between the student and teacher, there are some common elements. For instance, portfolios have a purpose (content or skills specific), are dynamic (flexible), are student centered, and are a tool for reflecting on learning. In addition, a portfolio's adaptability is based on the criteria selected for its construction. In other words, its uniqueness is determined by its purpose, its use, its appearance, and its intended audience. The adaptability of portfolios makes them effective assessment tools that are used to help students assess their own progress; assist teachers in making instructional decisions; communicate student growth to parents, teachers, and administrators; and help educators assess their program and curriculum goals.

Journals or Science Notebooks

Journals, also known as science notebooks, are practical, versatile tools for the science classroom. Entries can be structured by having students write a response to a specific question or content topic. They also can be unstructured with reflective writing of personal choice. In either case, science provides exciting content for connecting to language arts through expository writing in journal entries. In addition, the writing process provides a means for communication between the teacher and student or, if journal buddies are used, student to student. Many educators find that journal writing strengthens children's cognition by fostering the organization of language. Writing can prompt links to new information while helping students construct meaning of the classroom experiences and the natural world. Students build concepts by collecting information and applying their new ideas in this case through writing. Journal entries provide teachers with a practical tool for viewing students' thinking, dispositions, and skills. Writing about science content or processes can evoke metacognitive thinking in students, a form of internal dialogue that can develop deeper understanding. Journals or science notebooks enable students to describe their own ways of seeing and thinking about the science concepts constructed through their individual or shared experiences. In addition, teachers can use journals or science notebooks as an assessment tool for inquiry by having students include investigation notes like observations, drawings, charts, graphs, diagrams, and calculations (Klenchy, 2008; Shepardson & Britsch, 2001).

The following is an example of a journal entry written by a first grader. Ashia's class was exploring the question of which type of ball (ping-pong ball and golf ball) has the better bounce. The students were given two different kinds of balls to create a fair test to determine which ball bounces higher. They conducted four trials, spotting the height each time the ball bounced. They spotted how high the ball bounced by making a mark on a piece of chart paper taped to the wall. After the testing, Ashia wrote in her journal,

BULLETIN BOARD

Science Portfolio Ideas

Introduction

Table of contents

Lab reports (experiments or investigations)

Unit or chapter tests

Project examples of best work (self or teacher selected)

Photonarratives

Photographs of performance assessments

Written report

Book reports (on scientists, science concepts)

Samples of science journal entries or reflections

Drawings, diagrams, or models

Interactive historical vignette scripts

Options for selection:

(1) teacher-selected works to show snapshots of student work,
(2) teacher-determined assignments placed in the portfolio (i.e., All end-of-unit projects are placed in portfolio), or
(3) student-selected work demonstrating best efforts

TECH CONNECT: Elements of Science Notebooks

What might your K–8 students' science notebooks look like? Teachers from all over the country have uploaded examples of science notebook entries scanned from original student work. You can explore entries by topic and grade and find useful resources like assessment tools for science notebooks and lesson plans at http://www.sciencenotebooks.org/.

A relly good bouncer goes the highest. The pingpong was good bouncer. I think it bounce to the highest line. I think it bounced high because It is made of hard plastc because plastc can bounce good. The pingpong bal bounces better it bounced to the high line 4 times.

Ashia's entry describes the test her team conducted. Through this structured entry, asking the student's to use their data to determine which ball is the better bouncer, a teacher can gain important information on a student's knowledge of experimentation. Analyzing Ashia's entry, we find that she gives an operational definition of a "good bouncer." Can you find her definition? Yes, a good bouncer reaches the highest line. Furthermore, she shows the use of data (bounces to the highest line four times) to support the conclusion that a ping-pong ball is a good bouncer. Entries such as this one enable students to demonstrate their ideas about science content in a form that they can examine and even reconsider.

Journals or science notebooks can also be a source for questions that can inform subsequent teaching opportunities while capitalizing on the child's interests. The following questions were taken from student journal entries:

I learned that we can see layers of rock along side the roads, but why are some of the layers wavy? (Includes a drawing of a folded rock layers)
Shauntae, sixth grade

Why does the moon follow us in the car?
Tricia, second grade

How do cranes work? They can lift cars in the junk yard.
Cesar, fifth grade

What do baby spiders look like?
Brandon, Kindergarten

How do antibiotics work on germs?
Kenny, seventh grade

In some science classes, a teacher begins class by writing a question on the board. Students are given time to respond to the prompt at the beginning of the class. The journal prompt question can be designed to ascertain what students recall from an earlier lesson. They can also provide the teacher with important assessment into what the students already know about a topic that the teacher is preparing to teach.

Here are a few examples of science question prompts we have seen teachers use effectively in classrooms.

Yesterday we investigated changes in states of matter. What was the most difficult idea to understand?

If you had to describe a chemical change to your younger brothers or sisters, what would you tell them?

You have two metals. One is a magnet and one is magnetic material. Can you describe how you could tell which one is the magnet?

Describe places around your home and neighborhood that show weathering.

As you consider these prompts, look at each one and ask yourself what assessment data the teacher is trying to ascertain. Is there a question that seems to focus on improving instruction? Is there a problem-solving question? Is there a question assessing students' ability to apply knowledge? At other times, you may not want to focus on a specific content question; in that case, you might prefer to use general journal prompts such as the following:

What were the main points of the activity?

What did you enjoy most about the activity?

How might you use what you learned in the activity?

Did this activity make you think of any questions you would like to study?

Whether you choose to call these tools journals or science notebooks, they can make assessing science content an experience that is natural and personal. As you may have already figured out, however, it is impractical to assess all of the students' entries on a regular basis. A solution is to assess random entry selections, which, depending on the teacher's purpose, can serve as a formative assessment for guiding and improving instruction or as a summative assessment used at the end of a unit.

Alternative assessments, such as journaling about science, can be valuables tools for finding out what students know and are thinking.

Self-Assessment

Self-assessment refers to students judging the quality of their own work, based on evidence and explicit criteria, for the purpose of doing better work in the future. When we teach students how to assess their own growth, with known criteria, there is much to gain. Self-assessment influences learners' performance by improving self-confidence and motivation. Self-assessment is a critical skill for developing independent, lifelong learners. Unfortunately, it is often a neglected form of assessment. Through self-assessment, students may become aware of how their thinking can be applied in future work. Self-assessment can range from simple to complex, but effective self-assessment involves discussing with students how to

use or apply the criteria. Using examples helps students to understand what the criteria mean. With older students, the criteria can be negotiated, which fosters satisfaction and ownership. Finally, giving students' feedback on their self-assessments is an important step that assists them in setting improvement goals and plans to accomplish the goals. A general example of self-assessment is seen in the following:

SELF-ASSESSMENT

Date: _____ Topic: _____

Name: _____

Check one that best describes you:

___ Hey! I really was not very interested in the task (I did not want to do it).

___ My interest was "so so," or somewhat neutral (I could take it or leave it).

___ I was pumped! I couldn't wait to get started! (I was ready to do it).

What would you do to make it more interesting to you?

Check one of the following categories to describe yourself on the activity:

___ I did not do the work because_____

___ I only spent a little time thinking about the task because_____

___ I did it, but I had problems with _____

___ I did it and I think I understood it.

___ I completed it.

___ I completed the assignment and did more than was required.

How can I improve my work? My goals for improvement:

1.

2.

3.

What's a Rubric?

While discussing alternative assessments, we have used the term "rubric" many times. At this point, you might be wondering just what a rubric is or how one might use it. A rubric is an assessment tool created to analyze students' work.

A rubric is a guide for both teachers and students. It is shared before the task is assigned and the criteria are discussed so that the students are well versed on what is expected with the task. A rubric and its criteria are designed to provide students with specific feedback information regarding their strengths and weaknesses. It also provides the teacher with a clearer analysis of where instruction has been successful and where there may be weaknesses or gaps. Keeping in mind that rubrics provide students' feedback here are two general types of scoring rubrics: holistic and analytic.

Holistic scoring rubrics provide a single measure of mastery related to the quality of the students' work or performance as a whole. **Analytic scoring rubrics** provide separate measures based on criteria for several important dimensions of performance. So, how do I know when to use each one? There is no set rule: It depends on your instructional objective and your purpose. In general, holistic rubrics are used more often with younger students, in part because they contain less detail and are easier for young students to comprehend. The analytic rubric includes more criteria and detail, which makes it useful for assessing knowledge or skills that are more complex. Suppose students have been asked to design an experiment, similar to the test design in the fifth-grade exploration of changes in matter seen earlier in the chapter. The following are examples of holistic and analytical rubrics that could be used to assess students' skills in designing experiments (see Table 8.5).

Meaningful learning involves the use of a variety of assessments, both traditional and alternative. We believe that variety in assessment approaches is important in science classrooms. Though not addressed here, traditional testing is important, given the prevalence of statewide testing. Students must be taught to take traditional tests: To do less is to do them a disservice. So use both alternative and traditional assessments and evaluations, but remember no matter which type you use it should align to learning objectives and the instructional approach.

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Common Elements of Rubrics

- Rubrics measure stated learning or instructional objective(s).
- Rubrics display a range of levels of performance.
- Rubrics identify specific criteria or characteristics that determine the level at which the objective has been ascertained.

TECH CONNECT: Web-Based Rubric Generators

A variety of web-based tools exist for developing your own rubrics for your science classroom. The following sites are useful resources for creating rubrics; many include examples of rubrics that you can modify to meet your needs:

Rubistar (http://rubistar.4teachers.org/)

TeAchnology (www.teach-nology.com)

Tech4Learning (www.tech4learning.com)

Advantages of Using Rubrics

Developing a rubric is not easy, and takes preparation time in advance of the task. Furthermore, it often undergoes repeated revisions (a work always in progress) with

Table 8.5 Examples of Holistic and Analytic Rubric

Example of Holistic Rubric Experimental Design		Example of Analytic Rubric Experimental Design				
CRITERIA	**Scale**	**CRITERIA** **4-Excellent; 3-Superior;** **2-Average; 1-Needs work**	**4**	**3**	**2**	**1**
Hypothesizes, explains procedures, observes results, records results accurately, analyzes results, and draws conclusions accurately.	5	**Problem or Questions**: Clearly stated, complete, appropriate				
Missing one of the above criteria	4	**Hypotheses**: Provides testable, clear, multiple hypotheses				
Missing two to three of the above criteria	3	**Variables**: Identifies independent and dependent variable				
Missing four of the above criteria	2	Identifies control variables				
Missing more than four of the above criteria.	1	**Operation Definitions:** All pertinent operational definitions are identified, appropriate for the design, and observable or measurable				
		Procedures: Procedures are clearly stated. found in the appropriate sequence, can be repeated, and are appropriate for the question				
		Results and Conclusions: Records data, makes charts, and draws appropriate conclusions correctly				

continued usage. However, despite the preparation time and continued refinements, there are several advantages to using rubrics.

- Rubrics can help learners judge how well they have done.
- Rubrics make clear what is expected through specified criteria for both students and parents.
- Rubrics provide more learner feedback (both strengths and areas for improvement).
- Rubrics emphasize clear, specific criteria. The more details, the better.

Creating a rubric with effective criteria requires the use of clear, specific language. Using fuzzy terms in developing the criteria such as "a student writes an innovative question" causes confusion. The term "innovative" is difficult to define. Instead, use the term "testable question," which is clear and less subjective. Also, defining levels of quality in a rubric is often difficult, so spend time in advance thinking about how to describe the levels for clear understanding.

As you can see, there are many dimensions and elements to consider when choosing and designing assessments. From our own teaching experiences and conversations with teachers, we have compiled practical tips and important ideas about assessments for you (see Bulletin Board: Dee and Laura's Top Ten Assessment Tips).

As we move from the discussion of assessment in the explain stage, the next step in examining assessment is to have you take what you have learned and use it.

Elaborate

Course Evaluation Instrument: Is It Good Enough?

As students, you are all familiar with the course or instructor evaluations given at the end of your course. Your instructor should be able to supply a copy of the evaluation instrument to you. Examine the course or instructor evaluation form. Develop a holistic or analytic rubric for assessing the quality of a course evaluation instrument. Justify your selection of rubric, discussing its purpose and use. You might begin by examining the evaluation instrument in terms of the information it provides to the instructor for improving their course, or you might consider the instrument from the students' standpoint: Does the instrument provide opportunities or items that students think would be useful to the instructor? These are just a couple of questions to get you started, so do not be limited by them.

Evaluate

YouTube Media: Make an Assessment Video

This is a team project and it will involve self-assessment and group assessment. You and your team will create a short YouTube.com video or a PowerPoint slideshow (your choice) that addresses three of the chapters' objectives.

1. Distinguish between assessment and evaluation and the roles they hold in teaching and learning.
2. Describe and distinguish between forms of assessment (alternative, authentic, performance, traditional).
3. Demonstrate the alignment of instructional objectives with assessment.

You and your team members will need to discuss the objectives and the elements you wish to highlight in the project. You will need to assign roles and tasks to each member and set a timeline for completion. After the completion of the project, you will assess your own understandings and contributions to the group. You will also assess your team members. The final product will be uploaded on YouTube.com for class members to view.

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Dee and Laura's Top Ten Assessment Tips

10. KISS (Keep It Simple Silly) Keep the assessment short; remember, you have to provide feedback or score it, or both.
9. Use a variety of assessments, keeping in mind the diversity in your classroom.
8. Let the students know when and what you are assessing; rubrics demand that you do this.
7. Give positive feedback as well as feedback on areas for improvement.
6. Give frequent and timely feedback.
5. Use bright standout colors other than red for grading (red can signal negativity).
4. Use positive terms when conveying progress to the child and parents (see Bulletin Board: Assessment and Communicating With Parents).
3. Provide opportunities for self-assessment; cooperative teams need group and self-assessment.
2. Always balance the time for assessment preparation against what you can learn from the assessment.
1. Don't fall into the trap of grading all the students' work. Be selective and tell them when the assignment is important. With homework, randomly select work to grade.

Summary

In summary, assessment as discussed in the explain phase of this chapter places a demand on teachers to develop assessment literacy themselves. According to Rolheiser and Ross (2003), assessment literacy has been defined as (1) the capacity to collect and analyze students' data, (2) the ability to interpret the data, (3) the ability to make changes to improve teaching derived from those data, and (4) an openness to engage in external assessment discussions that have an impact on classrooms and schools. Developing assessment literacy facilitates teacher confidence about the defensibility of their evaluation practices and reduces feelings of vulnerability. It means that teachers are able to provide parents, students, and administrators with clear and detailed assessments, and are able to provide a rationale for the assessment choices they make in their classrooms. Educators who can clearly and respectfully discuss assessment issues with noneducators and educators are better able to link student learning and instructional approaches for the purpose of continuous improvement.

Annotated Resources

Miami Museum of Science

http://www.miamisci.org/ph/lpexamine1.html

This is an exciting web resource for alternative assessments for K–8 students. The site includes performance, authentic, portfolio, and journal assessment ideas and activities. The pH factor theme activities on acids and bases are engaging and appropriate for classroom use. Remember safety rules. The activities include web searches. A teacher's guide is available, but you will need to create your own rubrics.

Kathy Schrock's Guide for Educators: Assessment and Rubric Information

http://school.discoveryeducation.com/schrockguide/assess.html

This site has a tremendous amount of information on assessments and rubrics. You will find an assortment of alternative assessments for Sink and Float and Mystery Powder activities, as well as rubrics for oral presentations, self-assessments, and team assessments. A wide range of materials ready for use or easily adapted for the classroom is suggested.

Rubrican.com

http://www.rubrican.com

This site is designed for educators as a guide to creating project evaluations. It features rubrics for a range of subjects, including science. Click on the menu tab and you will find thirty or more rubrics associated with science experimentation or science content.

Edutopia (The George Lucas Educational Foundation)

http://www.edutopia.org/assessment

This is an exciting website with videos using top researchers on a variety of educational issues. You will hear and read about assessment from inside the classroom as well as from a leader in the assessment and evaluation field, Grant Wiggins. Check out Wiggins' presentation, "The idea of authentic assessment." This is an excellent website for preservice and inservice teachers.

Internet4Classrooms (Helping you use the Internet effectively)

http://www.internet4classrooms.com/

This site is useful for teachers and parents. The table of contents is divided by grade levels, with standardized testing examples for students. The site is intended to reinforce students' skills and content knowledge based on Tennessee standards. Don't let that deter you, if you are not in Tennessee: this is a very good site for students to practice traditional testing with good science examples. Simply cross-check the state standard and grade level you are interested in working with to those on the site.

National Science Education Standards, National Academies Press

http://books.nap.edu/openbook.php?record_id=4962&page=104

This site offers a free download of the *National Science Education Standard* text. Chapter 5, Assessment in Science, "provides criteria to judge progress toward scientific literacy. The assessment standards describe the quality of assessment practices by teachers and agencies to measure student achievement and opportunity provided students to learn science" (NRC, 1996, p. 75).

***Assessing science learning: Perspectives from research and practice* (2008) Edited by J. Coffey, R. Douglas, and C. Stearns**

http://www.nsta.org

This book resource available at the Science Store at www.nsta.org is appropriate for preservice and inservice teacher. It runs the gamut of issues surrounding assessment and evaluation with authentic examples and applications for the classroom. The book is divided into four areas of focus: (1) formative assessment in the service of learning and teaching, (2) classroom-based strategies for assessing students' science understanding, (3) high-stakes tests, and (4) assessment-focused professional development.

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