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Performance-Based Assessment

Teaching and assessment go hand in hand. In the classroom, teaching cannot be truly effective if it is not linked to some form of authentic assessment. Likewise, assessment is useless if it is not based on what has been, or is to be, taught. Although this may sound obvious, teachers sometimes forget the close relationship between the two.

Performance-based assessment requires students to demonstrate their learning and understanding by performing an act or a series of acts. This type of assessment is appropriate to use in a project-based, problem-based, or inquiry-based science classroom because it is consistent with the way students learn—by investigating a question or problem using tools and materials (i.e., performing an act). Since students in a project-based classroom learn by producing a product or performing an act, it is only fitting for them to be assessed using methods similar to those used to teach them—thus, aligning assessment with instruction. This article provides two common examples of performance-based assessments that science teachers can use in (or adapt for) their classrooms and a discussion of their strengths and limitations.

Assessment examples

Figure 1 represents a *structured-performance task*. In a structured-performance task, the student is provided with all necessary materials, a set of instructions, and assessment questions. Inquiry can be included in structured-performance tasks by asking students to design some of the experimental procedures themselves. The student is evaluated based on whether he or she

- follows directions correctly and uses suitable procedures,
- arrives at the appropriate answers, and
- understands and is able to explain the answers.

FIGURE 1

Structured-performance task.

Materials: You have a piece of potato, a bottle of water, three glasses (cups), sodium chloride (NaCl), a set of measuring spoons, a knife, and a watch.
Instruction: Design and perform an experiment to investigate what happens when a potato is placed in salt water and answer the following questions.
Assessment task/questions:

1. What happens to the potato when the NaCl concentration is at zero?
2. What happens to the potato when the NaCl concentration is very low?
3. What happens to the potato when the NaCl concentration is very high?
4. Write your results on the worksheet provided, including an explanation of your observations.

In Figure 2, a typical *open-ended performance task* is presented. In an open-ended task, a case or problem description is followed by a broad and open-ended task or question. Student responses vary because there is no single approach to solving the problem. The teacher should look for critical thinking, evidence-based reasoning, and problem-solving skills:

- Does the student have a clear procedure for addressing the problem?
- Can the student explain the procedure?
- Does the student provide evidence to support the proposed solution?

Scoring

Performance tasks can be scored to assess students' science-process skills as well as their understanding of science content. Scoring procedures vary depending on the focus and intended outcomes of the performance task.

For instance, the California Golden State Examination for laboratory-performance tasks focuses on mastery of scientific methods, problem solving, and understanding of scientific concepts (CDE 1993). The Connecticut Academic Performance Test focuses on science-process skills, such as the ability to define a problem, design an experiment, reason logically, make inferences and conclusions that are consistent with observations, perform with minimum errors or misconceptions, and communicate clearly (Greig, Wise, and Lomask 1994).

Strengths

Performance-based assessment allows the student to construct his or her own answers as opposed to simply choosing from a list. Both student and teacher are made aware in advance of the skills and knowledge to be learned, as well as the criteria for judging performance. Furthermore, performance-based assessment relies on multiple forms of testing. The work of students is compared to set criteria and not to other students' performances.

Cognitive research (Gardner 1993) indicates that most learning goes on within an active, rather than a passive, context and "that children construct knowledge from their actions on the environment" (Wadsworth 1989, p. 156). Performance-based assessment is therefore suitable for assessing nearly all types of learning because it allows students to demonstrate their competency in ways compatible with their learning experience. In project- or inquiry-based teaching, this method of assessment is particularly applicable for assessing science-process skills, such as the ability to ask questions, formulate hypotheses, design experiments, analyze and interpret data, use instruments, and present findings.

Performance-based assessment offers students choices in the selection of "topics or problems, to create and execute unique procedures, or to sequence aspects of performance electively. There is a belief that this element of choice will motivate students to perform well and may account for cultural differences in a more equitable manner than occurs in standard testing settings" (Baker, O'Neil Jr., and Linn 1993, p. 1212).

FIGURE 2

Open-ended performance task.

The Biagam dilemma.

Case: The (fictional) country of Biagam's only natural resources include fertile land and a beautiful river. The country imports most of its food, even though it could grow all the food it needs. The government of Biagam, with help from the World Bank, wants to build three dams on the Biagam River to supply water for irrigation and hydroelectric power. This would allow the country's farmers to grow food throughout the year, thus eliminating hunger and dependence on food imports. The hydroelectric power would provide electricity for manufacturing industries, which would create jobs and stimulate economic growth. Although many people in Biagam welcome the idea, some citizens and environmentalists fear that it would lead to an increase in insect-transmitted diseases, such as malaria and trypanosomiasis; destruction of aquatic plant species and fisheries habitat; and flooding of towns and cities near the river.

Assessment task/question: You are a scientist called upon to study the Biagam River watershed to help the government and people decide whether to go ahead with the Biagam River dams. Explain all the steps you would take to carry out your investigation.

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Limitations

A major technical limitation of performance-based assessment is its labor intensiveness. The development of this type of assessment involves creating and documenting the performance task, physically gathering materials and resources, and finally constructing and field-testing the performance task. All of these activities take time.

Another challenge in developing or using performance-based assessment is the standardization of scoring procedures. Evidence from research suggests that there is wide variability in the development of scoring procedures for performance-based assessment (Baker, O'Neil Jr., and Linn 1993; OTA 1992). Performance tasks vary greatly in terms of the subject matter addressed, the theories and procedures invoked, and the variety of possible solutions. Due to this variability, it can be difficult to evaluate student performance on a particular task and setting.

For large-scale performance-based assessment at the district or state level, the costs of administering and scoring are three to five times higher than those of conventional testing methods (OTA 1992). According to Shavelson and Baxter (1992), to obtain an accurate picture of a student's science performance, the student must perform between approximately 10–20 investigations. Because large-scale performance assessment is costly, in terms of both time and money, task-sampling poses a major problem. For example, in the state of California performance-based tests cost $50 per student, compared to $5 per student for standardized multiple-choice assessment (Seal 1993, p. 66). Some teacher training in judging student work, scientific observation, and defining performance criteria is necessary for successful performance-based assessment (which takes time and costs money).

Meeting assumptions

All assessment, including performance-based science assessment, carries some assumptions about the student and the learning environment. For instance, the structured-performance task shown in Figure 1 (p. 68) includes a visual section and is assumed to be suitable for learners who are visual with limited to moderate language and writing skills. Whereas in Figure 2 (p. 69), the underlying assumption is that students can read and understand textual material and are quite competent in writing. Therefore, it is the duty of the teacher to examine the underlying assumptions of each type of assessment and make sure that they are met before implementation in the classroom.

Despite its limitations, performance-based assessment is suitable for assessing nearly all types of science learning. It is particularly useful for assessing science-process skills, such as the ability to formulate a hypothesis; think critically; solve problems; design and conduct investigations; use instruments; collect, analyze, and interpret data; and document and present findings from research projects.

Performance-based assessment allows the student to construct his or her own answers as opposed to choosing from a group of answers. Both student and teacher are made aware of the skills and knowledge to be learned as well as the criteria for judging performance. Performance-based assessments "can be a learning experience in themselves. They can actually motivate students to learn more about the subject matter" (Doane, Rice, and Zachos 2006). In the real world, for example, we expect airplane pilots to not only demonstrate knowledge about the science of flight, but they also must log in many hours of flying time before being issued a full pilot's license. This is because flying an airplane is a performance-based activity. Science is also a performance-based enterprise, and we should expect our students to demonstrate scientific knowledge and understanding through performance.

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References

Baker, E.L., H.F. O'Neil Jr., and L. Linn. 1993. Policy and validity prospects for performance-based assessment. *American Psychologist* 48(12): 1210–1218.

California Department of Education (CDE). 1993. *Golden state examination: A guide for teachers and students.* Sacramento, CA: CDE.

Doane, W.E.J., R. Rice, and P. Zachos. 2006. Knowing when you don't know. *The Science Teacher* 73(4): 46–49.

Gardner, H. 1993. *Frames of mind*. 4th ed. New York: Basic Books.

Greig, J., N. Wise, and M. Lomask. 1994. The development of an assessment of scientific experimentation proficiency for Connecticut's statewide testing program:

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A paper presented at the Annual Meeting of the American Educational Research Association in New Orleans, Louisiana.

Office of Technology Assessment (OTA). 1992. *Testing in American schools: Asking the right questions*. Washington, DC: OTA.

Seal, K. 1993. Performance-based tests. *Omni*. December.

Shavelson, R.J., and G.P. Baxter. 1992. What we've learned about assessing hands-on science. *Educational Leadership* 49(May): 20–25.

Wadsworth, B.J. 1989. *Piaget's theory of cognitive and affective development*. 4th ed. New York: Longman.

Science in Politics

All teachers face the classic struggle of convincing students that material learned in class is important and relevant. Often, students seem to believe the only reason to understand a topic is to pass the next test.

Science teachers are fortunate because much of the material we teach comes up in everyday life. For example, the science involved in political issues is covered by daily newspapers, internet news sites, and the nightly news. Using the science in politics—particularly during a presidential election year—is a powerful method to engage students in science and demonstrate that the material they learn in class applies outside the classroom as well.

As a physics teacher, I work with juniors and seniors. An occasional focus on the involvement of science in politics is particularly relevant to these students, as a number of them will vote in the November elections. Feedback from students—through both conversations and surveys—has revealed that they grasp the importance of science when it is connected with solving local, national, and global problems.

Last fall, I had a group of juniors brainstorm current political issues that also had a clear reliance on some area of science. They were encouraged to consider the interdisciplinary nature of modern science. The list we developed included such topics as

- quality of air and water;
- disposal of solid wastes (including everyday garbage);
- new energy sources of all types and better energy efficiency and conservation;
- climate change (both at a fun-