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Performance-based Assessment for Assessing Science Learning

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Abstract

There has been a major shift in the area of assessment from 'outcome based assessment' to 'assessment for learning'. The purpose of assessment now is to obtain feedback in order to improve learning of students. The traditional outcome oriented methods of assessments through multiple choice questions, short answer questions or true/ false items do not provide any clue about the ability of students to solve real life problems by applying theoretical knowledge gained in the classroom situations. Performance-based assessment tasks provide opportunities to students to demonstrate their problem solving abilities by working individually or in groups. The aim of performance-based assessment is to integrate it with learning. During performance-based assessment, students get opportunities to apply various science process skills such as classifying, formulating hypotheses, interpreting data, and conducting an experiment. Another important highlight of the performance-based assessment is the process through which students go through while engaged in a task along with the product.

Introduction

A teacher teaches the concept of 'Force and Pressure" to her eighth standard students and asks questions after finishing the lesson to get an idea about their level of understanding. She finds that students were able to answer simple knowledge based questions but failed to apply the concept of 'Force and Pressure' in day-to-day life. After realising this, she focuses on everyday problems (e.g., why is it slippery to walk on ice? Why do we lubricate the engine of the vehicle? what is lubrication?) Students were then divided into groups to solve these problems and then discuss the outcomes in the class. Next day, she presents some other problems (e.g. what is the difference between weight and mass? why does a person weigh less on a moon?) and the students

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were expected to solve them in groups. While students work in groups, teacher moves among the groups of students and note down important observations which later will be used for assessment and feedback.

A biology teacher faced the same problem while teaching the concept of 'habitats' to ninth standard students. She divided the class into three groups. First group was given 'aquarium', second group was given 'terrarium' and the third group was given 'vivarium'. All the three groups were then expected to create their respective habitats keeping in mind the climatic conditions, adaptations of animals etc. Each group was given time to discuss their plans and implementation of these plans with their teacher. Lab attendant was also given the responsibility to assist each group. Students learned about different habitats while creating/ designing manmade ecosystems such as, aquarium, terrarium and vivarium. They also learned how a particular habitat offers food, shelter and other favourable conditions to plants and animals for their survival.

In the above two examples, students –

- were involved in real world contexts
- focused on 'bigger ideas' and major concepts, rather than isolated facts and definitions
- were involved in using science processes
- were given open ended questions
- were given opportunities to interact and collaborate
- were encouraged to make connections between concepts and ideas

The above two are examples of 'performance-based assessment'. What is performance-based assessment? How is it different from traditional assessment? Let us learn more about it.

What is Performance-based Assessment?

Performance-based assessments aim to model the real learning activities that we wish students to engage with, oral and written communication skills, problem solving activities etc, rather than to divide them into parts, as do multiple-choice tests; the aim is that the assessments do not distort teaching.

Performance-based assessment is different from traditional testing

Traditional outcome based tests are adopted for large scale testing of students on certain pre determined criteria. These tests are easily available, cheap, short, offer broad but shallow coverage, are easy to score and reliable. Performance-based assessment by contrast is:

time-consuming, tends to provide detailed information from multiple perspectives about a particular skill or area, (and, because of the time factor, depth may be exchanged for breadth); scoring is generally complex and usually involves the classroom teacher; standardization of the performance is not possible and

therefore reliability in the traditional sense is not high. All these features, which render performance assessment valuable for assessment to support learning, become problematic when performance assessment is to be used for accountability purposes (Frechtling, 1991).

Performance-based assessment is different from authentic assessment

Authentic assessment is performance assessment carried out in an authentic context, i.e., it is produced in the classroom as part of normal work rather than as a specific task for assessment. While not all performance assessments are authentic, but almost all authentic assessments are performance assessments. In other words, authentic assessment is a special case of performance assessment. An example of an authentic assessment would be a portfolio— the portfolio contains examples of actual student performance: 'best' performance elicited under normal classroom conditions in the classroom context. Meyer (1992) suggests that in using the term 'authentic assessment' assessors should specify in which respects the assessment is authentic: the stimulus; task complexity; locus of control; motivation; spontaneity; resources; conditions; criteria; standards; and consequences. According to Gipps, (1994), the list of these criteria may be very long but what becomes important in this case is addressing the question 'authentic to what?

During performance-based assessment, students can be assessed on the basis of products or performances. The end products for assessment are: display board, poster, exhibition, collage, photo essay, song, model, log/journal, recorded audio/video presentation, diagram or spreadsheet. The performances for assessment are: quiz, debate, group activity, multimedia presentation, power point presentation, story-telling, drama/ role-play, science lab demonstration and oral presentation.

Performance-based Assessment in Science

Why performance-based assessment in science? How are the basic principles of science in alignment with objectives of performance-based assessment? Science can arguably be defined as having at least three aspects: body of knowledge, process/ method, and a way of constructing reality, that is, nature of science (NOS), that distinguishes it from other disciplines or ways of knowing (Lederman & Khalick, 2001). These three aspects are different although an overlap between these three aspects is unavoidable. Performance-based assessment is in tandem with above mentioned three aspects of science, knowledge, process/method and nature of science. In performance-based assessment, it is the process which is equally important while they are engaged in solving a problem (product). Why? It is because; students make important decisions throughout

the learning process. Performance-based assessment assesses students on their ability to use/apply process skills such as classifying, formulating hypotheses, interpreting data, and conducting an experiment. For example, identification and classification of different insects, solving a problem scientifically, a project on 'pollution control measures in vehicles' in your city, a study on behavior of twins in your neighborhood, can be taken up for such assessments. To convey the correct NOS to students, assessment in schools must provide opportunities to get and use information. Older models of assessment were focusing upon definition of terms and concepts, and upon verification of skills. The science student's ability to find and to use information is an important part of scientific continuum and is basic to the study of science. Performance-based assessment reinforces the correct NOS by providing opportunities to get and use information in different authentic contexts.

Development of critical thinking and problem solving abilities of students is an important objective of school education. Involving school students individually or in small groups, in the act of solving a problem, or thinking critically about an event/incident, concept, or process, is known as performance-based assessment. In addition, performance-based assessment stimulates the development of other important dimensions of learning, namely the affective, social and metacognitive aspects of learning (http://institute-of-progressive-education-and-learning.org/k-12-education/based-learning). Let us find out.

During performance-based assessment affective (emotional) aspect of learning refers to motivation derived by students when they are involved in interesting and meaningful assessment tasks. They acquire confidence and develop a sense of satisfaction and pride while undertaking the assessment task.

The performance-based assessment involves peer interaction thereby enhancing their social skills for life. The group interaction further leads to social interactions and learning of social skills such as negotiating with others, accepting differences, reaching a consensus amicably, respecting others' opinions, individual contribution to the group effort and shared responsibility for task completion.

As for the metacognitive aspect of learning (pupils' thinking about their own learning), skills such as reflection and self-assessment also contribute to the learning process. When teachers require pupils to think about what they are learning, how they learn and how well they are progressing, they develop skills which make them more independent and critical pupils.

Performance-based Assessment in Science – the hows and whys?

There are SIX major characteristics of 'Performance-based assessment' which are given below –

1. Performance-based assessment is an assessment method in which students are required to perform skills and strategies in the form of hands-on assessment questions?
   (i) As an example for class 6th science, students were asked to investigate how a lactometer can be used to find out the amount of water in different milk samples provided to them. A Lactometer works on the principle of specific gravity of milk. It measures density of milk which is affected due to addition of water to milk. They were given different samples of milk and task to determine how the lactometer could be used to establish the correct density for a pure sample of milk. This hands-on task allowed students to conduct several investigations, make predictions, evaluate their work, and provide explanations for their responses.
2. Performance-based assessment strategies provide teachers with better knowledge of their students' strengths and weaknesses by giving teachers insights into students' process skill abilities.
   (i) Performance-based assessment assesses process(s) used along with the products presented at the end of the assessment. Products presented for assessment could include such tangible things as reports, models, posters, diagrams, spreadsheet, and written explanations and problem solutions. These products provide a teacher an understanding about the strengths and weaknesses of students along with the ability of students to apply process skills in a given situation.
3. Performance-based assessment allows students to collaborate, discuss, and refine their thinking in the assessment process. This is because much of the assessment process serves a teaching/learning function in a formative manner that leads learners to deeper, more accurate understandings.
   (i) For performance-based assessments, students work together while conducting science investigations and then evaluate each other's reports. They cannot accomplish these tasks without collaboration. It is beyond doubt that these types of collaborations on performance assessments better reflect skills required in the twenty-first century. Vygotsky (1978) believes that a learning community is important because learning takes place in a social context and relies on communication and interaction with others.
4. Performance-based assessment tasks are conceptual and therefore involve students in problem solving, higher level reasoning, critical thinking, and creativity.

(i) In performance-based assessment, students are apply knowledge gained in classrooms to real-world problems and while doing so they select required knowledge, approaches to apply this knowledge, and then providing explanations for the solutions obtained. The entire process involves reasoning, critical thinking and creativity (new designs, new strategies/ methods). For example, in an assessment question, science students are expected to discuss various reasons for environmental problems such as, pollution, ozone depletion, and global warming. They are also expected to discuss its relationship with various human activities. To predict its future implications on earth, and other animals and plants and to suggest measures for saving/conserving planet earth. Elucidate wherever possible. Prepare a report and present it in the class through poster and power point presentation followed by a discussion in the class.

5. Evaluation should be authentic. Assessment is authentic if it "... asks students to demonstrate knowledge and skills characteristic of a practicing scientist or of the scientifically literate citizen" (Lovitts & Champagne, 1990). Authentic assessments require that students perform tasks that relate to everyday life and demand the application of knowledge.

   (i) Yes, all performance-based assessments are authentic if undertaken in its right spirit. Students act like scientists and integrate scientific method in solving real life problems.

6. Performance-based or authentic assessment leads to deeper understanding of science, allowing teachers to know more about students' thinking and learning processes. This information can inform subsequent instruction.

   (i) Working in a group for solving real life problems is a highly motivating experience for students. It encourages them to learn and increases their achievement level. Such cognitively and emotionally satisfying experiences act as great reinforcers of learning.

What is a Performance Task?

A performance task is a structured situation in which stimulus materials and a request for information or action are presented to an individual, who generates a response that can be rated for quality using explicit standards. The standards may apply to the final product or the process of creating it. A performance assessment is a collection of performance tasks (Stecher, 2010). This definition has four important elements. First, each task must occur in a structured situation, meaning the task is constrained with respect to time, space, access to materials,

and so on. Second, each performance task contains some kind of stimulus material or information that serves as the basis for the response. In this respect, performance tasks can be very similar to multiple-choice items. Third, the task must have directions indicating the nature of the desired response. The directions can be part of the stimulus materials. Fourth, the task must prompt responses that can be scored according to a clear set of standards. It is usually the case that the standards are fully developed before the task is given.

There are TWO different types of performance tasks. These can be classified as –

1. **Classifying based on Stimulus Materials and Response Options** It is a two-way classification scheme based on the structural characteristics of the task, particularly the nature of the stimulus materials and the nature of the response options. (This scheme is inspired by the work of Baxter & Glaser, 1998, discussed subsequently) The stimulus materials can be classified in terms of complexity along a dimension that runs from simple to complex. (See table 1) A physics task that asks the student to solve an equation for x represents a relatively simple stimulus. Similarly, the response options can be classified in terms of freedom along a dimension that runs from constrained to open. There can be constrained responses such as, a short answer question on photosynthesis. In comparison, a life science task in which students are given a set of leaves to observe and are asked to create at least two different classification schemes and arrange the leaves into groups based on each scheme offers a relatively open range of responses. By crossing the stimulus and response dimensions, we create four quadrants that can be used to classify all performance tasks. A written, short-answer (fill in-the-blank) question is an example of a relatively simple, relatively constrained task. A Physics word problem that requires setting up equations, using a graphing calculator, and other calculations is an example of a relatively simple, relatively open task.

Table 1: Classification based on Task Structural Characteristics

(Hammond, Linda & Adamson, 2014)

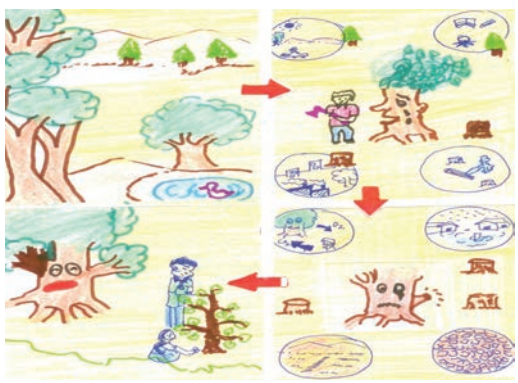
Stimulus/ Response	*Simple*	*Complex*
Simple	Simple Stimulus	Simple Stimulus
	Simple Response	Complex Response
Complex	Complex Stimulus	Complex Stimulus
	Simple Response	Complex Response

2. **Classifying based on Content Knowledge and Process Skills** Baxter and Glaser (1998) suggest a way to classify science performance

tasks by their cognitive complexity, and this approach could be used more generally. They divide the science assessment space into four quadrants depending on whether the process skills demanded are open or constrained and whether the content knowledge demanded is lean or rich. They provide examples of science tasks corresponding to each quadrant. For example, "Exploring the Maple Copter" is an example of a content-rich and open-process task. In this task, high school physics students are asked to design and conduct experiments with a maple seed and develop an explanation of its flight for someone who does not know physics. The two-way content-process classification is helpful for characterizing the cognitive complexity of performance tasks. This distinction is useful when thinking about the inferences that are appropriate to make from scores on performance assessments and the kinds of information that would be needed to validate those inferences.

Some Examples of Performance Assessment Tasks

1. *Performance Tasks to Assess Science Knowledge:* Conceptual understanding of the natural world is a key goal of elementary school science. Understanding principles, concepts is important because it further helps in application and interpretation of these facts/ principles in different situations. Therefore, simple tasks such as fill-in-the blanks, short answer questions, locate the following help in assessing their science understanding.
2. *Pictorial Interpretations:* The teacher shows a picture and asks students to explain it– what do you see in this picture? (any four points) who is responsible? (one point) What can be done to restore it back? (any two points)



Element	0-7 Points	
Comparison of 4 parts of the picture	Any four observations related to the picture such as cutting of trees, change in soil quality, climate, causing floods, constructing houses etc. (0-4 points)	
Who are responsible for changes?	Man/human activities (0-1 point)	
What can be done?	Any three points such as planting more trees, avoiding cutting of trees (0-2 points)	
Scoring	Outstanding Satisfactory Needs improvement Unsatisfactory	6-7 points 4-5 points 2-3 points 0-1 points

3. *Assessing Data-Gathering Processes with a Plant Growth Task:* In order to assess the application of processes of science, a project on plant growth is planned for students. In the performance task, students were expected to observe pairs of growing plants over a period of time and answer questions about them. During this task students measure, record data, and determine patterns and trends from the data. The products to be judged are the students' oral or written answers to the questions. A rubric can be prepared for assessing their answers.

4. *Using Performance Tasks to Assess the Application of Inquiry Procedures and Science Processes:* Involving students in inquiry activities during science learning is all the more important today. Assessing inquiry procedures and science processes, both during formative as well as summative assessment, is an important part of science school programmes especially at elementary stage. For example, students are given six different fruits (ranging from unripened stage to fully ripe form) and given some questions such as (a) observe them for few days and note down changes in each of these fruits; (b) test these fruits for starch and sugar on 1st day, 3rd day, 5th day and 7th day. Record your observations and explain these observations.

The assessment of these inquiry procedures can be done by focusing on long-term conceptual goals of this lesson. 'Conversion of starch into sugar during ripening of fruits' is the guiding concept for this problem-based inquiry. The responses of the students, in this case, will be analyzed to understand students' thinking and will be used appropriately by the teacher for making decisions for further improving their learning (a basic requirement for assessment of inquiry).

5. *Assessing Multiple Objectives through Performance Assessment:* when students acquire required knowledge and conceptual clarity about scientific facts then they can use this knowledge and understanding for creating new or different products.

   (i) Making Models: Models depict students' understanding of natural objects, organisms, living processes, structural features and their abilities to apply science processes and inquiry procedures. Therefore, these models are excellent products for assessment. For example – solar system model, physiological systems of human body, stages in water purification etc.

   (ii) Student Demonstrations: Students can again exhibit their understanding of scientific concepts and their

interrelationships by planning, manipulating and demonstrating with scientific supplies and equipments such as electric circuit, movement of light in a straight line, solubility of different solutes in water, separation of iron and sulphur mixture by bringing a magnet, separation of different substances by using different techniques.

(iii) Projects: Students projects can convey a lot about students' conceptual clarity as well as thinking. Projects provide the teacher with insight into how well students have learned, recorded and applied their knowledge. For example, You are an agricultural scientist appointed at an agricultural institute in a rural area. Your task as an agricultural scientist is to choose two crops to be grown in mixed cropping in a given piece of land keeping in mind their duration, growth habits, root patterns, water needs, demand for nutrients, improvement in soil fertility, variety of produce, increase of yield and minimizing pest damage. Submit a report explaining the selection of these two crops for the selected area. Submit appropriate evidences in favour of your selection (such as soil testing, weather conditions, nutrient requirement of plants to be grown for mixed cropping). This written report submitted by students can be assessed by developing a rubric.

Summing up

Assessment is an integral part of teaching-learning process. It provides a crucial feedback to the teachers about learners' level of progress. The theoretical understanding of the concepts must help the learners in solving real life problems. Science process skills such as, observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, and communicating, are not only useful in science, but in any situation that requires critical thinking. Performance assessments also involve assessing students on their ability to use science skills. Furthermore, performance-based assessment focuses on the process pupils go through while engaged in a task as well as the end product, enabling them to solve problems and make decisions throughout the learning process. There are a number of methods which can be used for performance-based assessment in science.

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