

The Potential of Assessment in Science

Vishnu Agnihotri, Nishchal Shukla, Apoorva Bhandari



Background

Before we speak of assessment in science, we need to understand what the goals of science education are, so that we may know what it is that we want to assess. The National Focus Group (of the National Curriculum Framework) document on the teaching of science lists “observation, looking for regularities and patterns, making hypotheses, devising qualitative or mathematical models, deducing their consequences, verification or falsification of theories through observation and controlled experiments” as the steps of the scientific method. The above stated process skills have to be developed while working on certain content, indeed, content in multiple areas. For instance, the skills of observation and looking for regularities (similar to classification into groups), for example, can be developed both while working with different types of leaves, as well as while working with different type of materials like glass, wood, steel, etc.

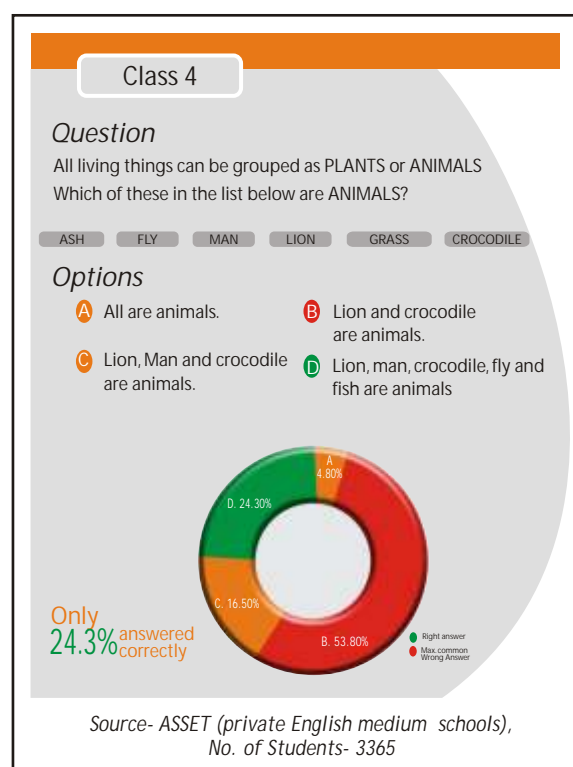
Stated simply, process and content are both important to science education. Thus science assessment, too, must focus on these two aspects, whether the assessment is a large-scale standardized test, a school quiz, or an informal assessment made by a science teacher, as she walks around class, listening to students. The focus in both teaching and assessment should be on important ideas, concepts and skills. The curriculum should not be, as somebody has said, “a mile wide, and an inch deep”.

Some insights from our experience in large-scale assessment

We share some insights we have got from our experiences in large-scale assessment, along with

examples. We hope this highlights the importance of the feedback that we can get from such assessments.

Lay ideas dominate scientific ideas

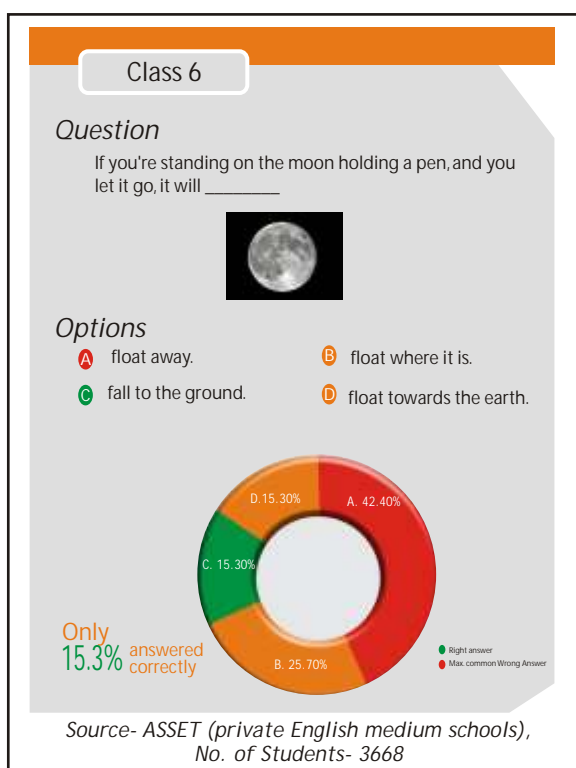


The results of the above question show that over 50% of the students believe that only 'lion' and 'crocodile' are animals, and 'man', 'fly' and 'fish' are not animals. Common comments by students are that 'man used to be an animal, but no longer is', 'fly is too small to be an animal', 'fish is an aquatic creature'. This indicates that the lay usage of the term 'animal' dominates children's thinking, even though they may have been taught, in a science class, that all living things are grouped into plants and animals (which, in fact, is also stated in this question); the distinguishing characteristic being that plants make their own food from sunlight, whereas animals must depend on plants or other animals for food.

These results are not a comment on the ability of children, but highlight the need for educators to

recognize the strong influence that lay terms and ideas have on children, and reflect on instruction that can address this. For example, getting such feedback might lead a science teacher to spend time eliciting student ideas on what an 'animal' is, clarifying the difference between the 'scientific' and lay meaning of a term, and stressing on the similarities between a man, a fly and a lion that qualify all of them to be 'animals'.

Prior mental models dominate



These results and subsequent interviews with students show that the image of astronauts floating in space or spacecrafts has strongly influenced the mental models of children (and many adults). There are also many misconceptions about gravity and weight; it is seen more as a property of the object which 'allows it to fall', rather than as an effect of gravity. Many of the same students who answer this question wrongly can comfortably tell you that 'the gravity on the moon is 1/6th that on the earth'. If educators can recognize that children come to school with 'ideas of their own', then they can see their task as helping students to assess the efficacy of their ideas (or

mental models) and help them replace these with more scientific mental models. A video series produced by the Harvard Smithsonian Centre for Astrophysics demonstrates this powerfully (<http://www.learner.org/resources/series26.html>). We have also produced a series of films based on student interviews, and can share a copy of these on request.

Other examples of misconceptions and their sources

Several such examples are seen in our work with both private English medium schools as well as the government schooling system. The following is a quick peek into some other types of examples-

- Textbook context rules ideas - Most textbooks, for the primary level, always refer to evaporation in the context of the water-cycle. This leads children to believe that 'evaporation' and the 'water cycle' are synonymous. Consequently, they do not believe that evaporation can occur from a glass of water, or a puddle, etc.
- Poor real-life observation - Time and again, student response data show that children are not encouraged to learn science through careful observation of day-to-day phenomena, like for example, how shadows are formed.

One interesting example is from a study we did on municipal schools across five states in the country. Students of Class 6 of these states were asked the question (in their local language)-

Which of these is furthest away from us?

- A. clouds
- B. a flying crow
- C. the Sun
- D. the moon

30-50% of students answered that clouds are furthest away from us! The response data to this question makes us wonder whether schools are actually helping in learning at all!

Assessment data - a goldmine of insights

We believe that as more and more stakeholders recognize the power of large scale assessment, there will be further investments of effort into deriving many more types of insights from assessment data. We share, below, one example of what else might be possible to glean from data. This analysis shows how even five years of schooling has virtually no impact on addressing a misconception on the concept of respiration.

The question asked of students from Class 4 to Class 10 was -

Which of the following are examples of respiration?

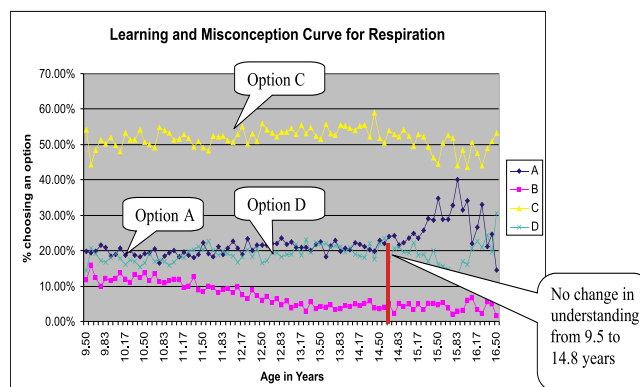
1. Humans use oxygen and release carbon dioxide.
2. Plants use carbon dioxide and release oxygen.
3. Burning dry leaves uses oxygen and releases carbon dioxide.

- A. only 1
B. only 2
C. only 1 and 2
D. 1, 2 and 3

The correct answer is A- Only 1. Process 2 is the process of photosynthesis; even many adults do not realize that plants are taking in oxygen and giving out carbon dioxide simultaneously and continuously in order to respire and provide energy for their life processes. Process 3 is the process of combustion.

The student response data across all these classes is shown in the graph below. Students were aged from 9.5 to 14.8 years.

The data clearly show that children continue to answer C (thinking that photosynthesis is 'how plants respire'), and there is virtually no change in their understanding across over 5 years of schooling. And this is a period during which they learn about the entire human body and all its systems including the respiratory system. They also learn about plants and photosynthesis along



with the chemical reactions taking place. They learn about the carbon cycle, and the basics of chemistry and chemical reactions. But clearly, there's little to show that all this is actually being 'learnt'.

Parting thoughts : Interpreting and acting on assessment data

As we have seen above, assessment does provide valuable data and insights into how we are progressing towards our goals as an individual, class, school, or a nation. Creating a culture of data-based analysis and decision-making can lead to a focusing of efforts and fruitful issue-based dialogue between stakeholders.

However, one needs to be aware of the risk of blindly accepting assessment data without understanding the context, and reacting to data in a knee-jerk fashion. When scientifically generated assessment data points to significant gaps in learning, defensiveness can be a natural reaction, especially when 'official' statistics show a much rosier picture. For a system to accept the 'true metric', and face the reality of the current situation, can be scary, but there is no choice if we truly want to improve learning. As Jim Collins, the author of 'Good to Great' says, "Great organizations confront the Brutal Facts (Yet Never Lose Faith)". We could extend this to systems as well.

While interpreting assessment data, do make sure you ask relevant questions, such as - What was the question given? How was it administered? Under what conditions did students take the test? How was the sampling done? How has the statistical validity been determined? What do field interviews with students

say? It is only when one gets into such details, can one get an accurate and well-rounded view of what the data is telling us.

Assessment as an integral part of learning

Is assessment only about results from large scale tests? Not at all! Assessment is an integral part of the learning process. It is about the teacher and learner getting feedback; it is about recognizing and clarifying goals, and always keeping the 'end in mind'. In fact, it is impossible to separate assessment from the process of learning.

Our experience is clearly beginning to show that assessment can be used for learning in new and different ways. We are currently working with children in both private and government schools with a question-based adaptive learning system called Mindspark that has been developed for Maths. The system uses 'finely-graded questions', meaning questions that successively address higher and higher concepts but with a very, very slight increase in complexity between the concept(s) tested in one question and the next. Such question-based assessment systems can be valuable tools to provide personalized learning support to complement group teaching that

happens in the class. Rigorous early tests are showing encouraging results that children like to answer the questions, and there is a statistically significant improvement in their learning levels. The development of Mindspark Science modules is currently underway.

We hope this article has shed some light on the power of assessment in science, and assessment in general, and encourages a deeper investigation into assessment practices and the use of assessment data by all stakeholders in education.

Vishnu Agnihotri, Educational Initiatives, heads the team that develops the ASSET diagnostic test taken by private English medium schools across the country. He can be contacted at vishnu@ei-india.com

Nishchal Shukla, Educational Initiatives, senior member of the ASSET team, works in both Science and Maths assessment, with a special interest in learning about 'how children think', through student interviews. He can be contacted at nishchal@ei-india.com

Apoorva Bhandari, Graduate Student, Cambridge University, UK, is associated with Educational Initiatives on various research projects, with a special interest in neuroscience, cognition and learning models. He can be contacted at apoorva@ei-india.com

