ASSESSMENT IN SCIENCE AND MATHEMATICS AT THE ELEMENTARY STAGE

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Introduction

Assessment defined as "the systematic process of gathering information about what a student knows, is able to do, and is learning to do" is an integral part of classroom instructions. Broadly, any activity or experience that provides information about student learning is also termed as assessment. This gives the teacher a clear idea about student's progress through continuous observation of students in action and not only through formal tests, examinations and projects.

The major purposes of assessment are to look at the teaching strategies and improve learning, and to monitor student's progress in achieving learning outcomes at the end of a class or course of studies. This nowhere should tend to evaluate and label student's performance .

Learning is a natural process and takes place with varied and targeted experiences. This is more true in case of science and mathematics learning — these subjects are exploratory in nature. To assess students' science and mathematics knowledge, skills and strategies, and attitudes, teachers require a variety of tools and approaches. They ask questions, observe students engaged in a variety of learning activities and processes, and examine student work in progress. They also engage students in peer-assessment and self-assessment activities. The information that teachers and students gain from assessment activities informs and shapes what happens in the classroom; assessment always implies that some action will follow.

Preparation of Assessment for Learning

Since assessment is an integral part of instruction, teachers should plan it along with their plan for instructions in and outside classroom. They select assessment purposes, approaches and tools in conjunction with their choice of instructional strategies. In developing assessment tasks and methods, teachers determine —

- What is to be assessed?
- Why it is assessed?
- How the assessment data will be used?
- Who will gather the assessment information — teachers, students or other stakeholders?

- What type of activities or tasks will encourage students to demonstrate their learning in effective ways?
- How the learning progress be recorded and reported?

Characteristics of Assessment for Learning

Assessment provides important information about teaching and learning. It helps focus effort on implementing strategies to facilitate learning both inside and outside the classroom. The assessment in science and mathematics has some specific characteristics due to the nature of these subjects:

1. Conforms to the criteria that students know and understand, suits to their strengths
2. Integral to instructions
3. Based on meaningful tasks, science-learning processes and contexts
4. Based on a wide range of tools and methods and be multi-dimensional
5. Collaborative involving students in the process
6. Focused on strengths of learners and what they can do
7. Continuous and comprehensive
8. Make use of technology to ease the process

These seven characteristics of assessment have been explained below:

1. Assessment for learning should be in conformity with the criteria that students know and understand, and suits to their strengths

Before an assignment or test, the assessment criteria must be clearly established and made explicit to students so that students can focus their efforts according to criteria. In most of the cases the students can themselves decide the assessment criteria in consultation with the teacher. Technically, such criteria are called rubrics, which are explaned below.

Rubrics

The rubric developed for the purpose of assessment should be according to the task and the learning outcomes. The performance can be graded in multiple point scale and these points should be made part of the rubric. Each assessment task should test only those learning outcomes that have been identified to students. This means, for example, that laboratory skills tests need to be devised and marked to gather information about students' laboratory skills, not their ability to express ideas effectively in writing a laboratory report. In a task related to solving a problem, there can be various sub-tasks which reflect student's level of learning like, ability to describe the problem in mathematical terms, ability to cull out the unknowns, ability to connect known with unknown and find unknowns by using appropriate mathematical tools, and lastly to describe the solution in real life situation. These sub-tasks define different levels of learning and can be shown in the rubric.

2. Assessment for learning should be integral to instructions

As is evident from the definition of assessment, it provides answers to the questions like "What do I want my students to learn?" and "What can my students do to show they have learned it?"

So, the process of assessment depends on the objectives of the assessment. While studying science and mathematics, a child acquires/

builds up the following and the process of assessment should be accordingly decided:

- **Factual knowledge**: The fact-based recall may be termed as declarative knowledge which can directly be assessed by traditional methods. But simply memorisation of the declarative/factual knowledge related to science does not serve the higher purpose of science and mathematics education, i.e., fostering scientific attitude and development of reasoning. What is more important is whether students understand and are able to apply this knowledge. For example, by learning about deforestation, it is more important that they respond to and interpret what deforestation means for them personally and environmentally, and that they use appropriate terminology with ease to enrich their own writing —rather than reproduce—a definition of deforestation. Designing tools that test the application of declarative/factual knowledge is a big challenge that many teachers face.
- **Procedural/process knowledge**: Science and mathematics learning require skills to adopt/adapt applicable procedures/ processes. Tools that are designed to test factual knowledge cannot effectively assess skills, strategies and processes. For example, rather than trying to infer student processes by looking at final products, teachers assess procedural knowledge by observing students in action, by discussing their strategies with them, and by gathering data from student reflections. For example, a child simplified a fraction $\frac{26}{65}$ as $\frac{2\cancel{6}}{\cancel{6}5}$ and answered $\frac{2}{5}$. Here the final outcome of the process is correct but the process itself is not correct. Science and mathematics are full of such procedures that provide direct algorithms to solve problems. The assessment of procedures followed by a child to reach to a conclusion gives ideas to the teachers about the way child is thinking/ learning.
- **Attitudes and habits**: Attitudes and habits are implicit in what students do and say. Assessment tools typically describe the behaviour that reflect attitude and habits of literate individuals. They identify attitudes and habits of mind that enhance science and mathematics-related language learning and use, and provide students with the means to reflect on their own internal processes. For example, rather than assigning global marks for class participation, teachers assess learning outcomes related to students' effective contributions to large and small groups.

Assessment for learning intends to inform students about their level of learning and to help them focus on important aspects of learning. The students focus only on those things which a teacher assesses. If teachers assess only the elements that are easiest to measure, students may focus only on those things. For example, if science and mathematics learning place a high value on collaboration, creativity and divergent thinking (learning outcomes that may be more difficult to measure), then assessment tools and processes must reflect those values. The ways teachers assess (what and how) inform students of what is considered important in learning.

3. Assessment for learning should be based on meaningful tasks and science and mathematics-learning processes and contexts

Assessment tasks in science and mathematics should be meaningful and contextual to a student. These tasks should worth mastering

for their own sake rather than tasks designed simply to demonstrate student proficiency for teachers and others. Through assessment, teachers discover whether students can use knowledge, processes and resources effectively to achieve purposes. Therefore, teachers design tasks that replicate the context in which knowledge will be applied in the world beyond the classroom.

Assessment tasks should therefore, test the way child's understanding of a subject has deepened, and of his/her ability to apply learning but not to only test the information student possesses. They demonstrate to students the relevance and importance of learning. Performance-based tests are also a way of consolidating student learning. The teaching focussing on examination will be of less concern if assessment processes focus on assessment of student knowledge, skills and strategies, and attitudes.

4. Assessment for learning is based on wide range of tools and methods and be multi-dimensional

Assessment in science and mathematics must recognise the complexity and holistic nature of learning. To compile a complete profile of each student's progress, teachers gather data using many different means over numerous occasions through various tools.

Student profile is one of the tools which involves both students and teachers in data gathering and assessment. A student's profile gives a systematic idea of child's learning progress and also indicates her/his strengths and weaknesses. The assessment for learning includes observation of processes/procedures through classroom/ laboratory discussions among children, presentations and peer assessment. The details of some of the tools are given next:

- **Observation** of students is an integral part of the assessment process. It is most effective when focused on skills, concepts and attitudes. Without record keeping, however, observations and conversations can easily be forgotten. Making brief notes on index cards, self-stick notes, or grids, as well as keeping checklists, helps teachers maintain records of continuous progress and achievement.
- **Interviews** allow teachers to assess an individual's understanding and achievement of the prescribed student learning outcome(s). Interviews provide students with opportunities to model and explain their understandings. Interviews may be both formal and informal. Posing science-related questions during planned interviews enables teachers to focus on individual student skills and attitudes. Students reveal their thinking processes and use of skills when they are questioned about how they solved problems or answered science questions. Using a prepared set of questions ensures that all interviews follow a similar structure. It is important to keep a record of student responses and/or understandings.
- **Performance assessment / student demonstration:** Performance tasks provide students with opportunities to demonstrate their knowledge, thinking processes and skill development. The tasks require application of knowledge and skills related to a group of student learning outcomes. Performance-based tests do not test the information that students possess, but the way their understanding of a subject has been deepened, and their ability to apply their learning in a simulated performance. A scoring rubric that includes a scale for the performance of the task helps organise and interpret evidence. Rubrics allow for a

continuum of performance levels associated with the task being assessed.

- **Project reports:** Science journal writing provides opportunities for students to reflect on their learning and to demonstrate their understanding using pictures, labelled drawings and words. They can be powerful tools of formative assessment, allowing teachers to gauge a student's depth of understanding. In this document, direct questions/scenarios frame the science journal suggestions.
- **Rubrics/checklists:** Rubrics and checklists are tools that identify the criteria upon which student processes, performances or products will be assessed. They also describe the qualities of work at various levels of proficiency for each criterion. Rubrics and checklists may be developed in collaboration with students.
- **Visual displays:** When students or student groups prepare visual displays, they are involved in processing information and producing a knowledge framework. The completed poster, concept map, diagram, model, etc., is the product with which teachers can determine what their students are thinking.
- **Laboratory report:** Laboratory reports allow teachers to gauge the ability of students to observe, record and interpret experimental results. These tools can aid teachers in determining how well students understand the content.
- **Pencil-and-paper tasks:** Quizzes can be used as discrete assessment tools, and tests can be larger assessment experiences. These written tasks may include items such as multiple choice questions, completion of a drawing or labelled diagram, problem solving, or long-answer questions. Ensure that both restricted and extended, expository responses are included in these assessment devices.
- **Research report/presentation:** Research projects allow students to achieve the learning outcomes in individual ways. Assessment should be built into the project at every stage, from planning, to researching, to presenting the finished product.

5. Assessment for learning is collaborative involving students in the process

Self-assessment of learning and making judgments about one self is important way of assessment for learning. This cultivates the development of students' autonomy as lifelong learners. It helps them make judgments about their own learning, and provides them with information for goal setting and self-monitoring.

Teachers increase students' self-assessment habits by:

- involving students in developing assessment criteria.
- involving students in peer assessment.
- having students use tools for reflection and self-assessment at every opportunity like self-assessment of portfolio items.
- establishing a protocol for students in order to reduce the dissatisfaction on teacher assigned marks or performance level.

- **Group/peer assessment:** Group assessment gives students opportunities to assess how well they work within a group. Peer assessment gives them opportunities to reflect on one another's work, according to clearly established criteria. During the peer assessment process, students reflect on

their own understanding in order to assess the performance of another student.

- **Self-assessment** is vital to all learning and, therefore, integral to the assessment process. Each student should be encouraged to assess her or his own work. Students apply known criteria and expectations to their work and reflect on results to determine their progress towards the mastery of a prescribed learning outcome. Participation in setting self-assessment criteria and expectations helps students to see themselves as scientists and problem-solvers. It is important that teachers model the self-assessment process before expecting students to assess themselves.

6. Assessment for learning focused on strengths and knowledge of learners

To assess what students have learned and can do, teachers need to use a variety of strategies and approaches, such as the following:

- Using a wide range of instruments to assess the multi-dimensional expressions of individual student's learning, avoiding dependence on recall after rote memorisation.
- Providing opportunities to learn from feedback and to refine their work.
- Examining variety of student's work in assessing any particular learning outcome to ensure that data collected are valid bases for making generalisations about student's learning.

Developing student profiles from outcome-referenced assessment, which compares a student's performance to predetermined criteria, and self-referenced assessment, which compares a student's performance to her or his prior performance.

- Avoid assigning zero marks for incomplete work as this does not communicate accurate information about the student's achievement of science and mathematics learning outcomes. Unfinished assignments may be caused due to personal or motivational problems that need to be addressed in appropriate and alternative ways.

7. Assessment for learning is continuous and comprehensive

Continuous assessment provides ongoing opportunities for teachers to review and revise instruction, content, process emphases and learning resources.

Managing classroom assessment

Assessment is one of the greatest challenges science teachers face. The practices that make science classrooms vital and effective—promoting student choice, assessing processes and assessing the subjective aspect of learning—make assessment a complex matter.

Systems and supports that may assist teachers in managing assessment include —

- dispensing with ineffectual means of assessment
- using time savers
- sharing the load
- taking advantage of technology
- establishing systems of recording assessment information

8. Using technology for assessment

Teachers need to question the efficacy, for example, of writing lengthy commentaries on summative assessment of student projects.

Detailed comments are best —

- provided as formative assessment, when students can make immediate use of the feedback.
- shared orally in conferences, which provide opportunities for student-teacher discussion. The time spent in assessment needs to be learning time, both for teacher and student.

Using time savers

Many effective assessment tools are time savers. Developing checklists and rubrics is time-consuming; however, well-written rubrics may eliminate the need to write extensive comments, and may mean that student performances can be assessed largely during class time. Some of the assessment tools in the professional literature related to science assessment may also be useful.

Sharing the load

While the ultimate responsibility for assessment rests with the teacher, student self-assessment also provides a wealth of information. Collaborating with students to generate assessment criteria is part of effective instruction. Two senior students may develop checklists and keep copies of their own learning goals in an assessment binder for periodic conferences. Students may be willing to contribute work samples to be used as models with other classes.

Collaborating with other teachers in creating assessment tools saves time and provides opportunities to discuss assessment criteria.

Taking advantage of technology

Electronic tools (e.g., audiotapes, videotapes, and computer software) can assist teachers in making and recording observations. Word processors allow teachers to save, modify and reuse task-specific checklists and rubrics.

Formative and Summative Assessment

Assessment can be formative or summative.

- Formative assessment is based on data collected before an instructional sequence is completed. Its purpose is to improve instruction and learning by:
  - providing students and teachers with the information about students' progress in accomplishing prescribed learning outcomes.
  - evaluating the effectiveness of instructional programming content, methods, sequence, and pace.

  Formative assessment majorly focusses on assessment for learning and as learning (discussed earlier in this paper).
- Summative assessment (evaluation) is based on an interpretation of the assessment information collected. It helps determine the extent of each student's achievement of prescribed learning outcomes. Evaluation should be based on a variety of assessment information. Summative assessment is used primarily to:
  - measure student achievement
  - report to parent(s) or guardian(s), students, and other stakeholders
  - measure the effectiveness of instructional programming.

  Summative assessment provides useful information/data about what the student has learnt. This is called assessment of learning.

Establishing Systems for Recording Assessment Information

Collecting data from student observations is especially challenging for Senior Years teachers, who may teach several classes of students in a given semester or term. Teachers may want to identify a group of students in each class for observation each week. Binders, card files, and electronic databases are useful for record keeping, as are self-stick notes recording brief observations on student files, which can later be transformed into anecdotal reports.

Teachers may also want to develop comprehensive forms for listing the prescribed learning outcomes, and for recording data. Online opportunities for the creation of lesson or unit plan and selection of assessment strategies are also available on various web portals.

The above discussion is aimed at providing a holistic view of assessment of science and mathematics learning in elementary classes. The teachers and other users of this paper are expected to make appropriate adaptations according to their needs and the nature of assessment.